# USING A VIRTUAL REALITY ENVIRONMENT TO TRAIN SPECIAL EDUCATORS WORKING WITH STUDENTS WITH AUTISM SPECTRUM DISORDERS TO IMPLEMENT DISCRETE TRIAL TEACHING

by
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## ABSTRACT

Autism Spectrum Disorder (ASD) is the fastest growing disability category receiving special education services in schools with a current prevalence rate of 1 in 68 children in the United States, a 30% increase since 2012. Teachers of students with ASD and other disabilities are encouraged by law to use evidence-based practices (EBPs). In order to be effective, special educators must be knowledgeable about and able to implement EBPs that address disability-specific needs so they can provide intensive, explicit instruction within the broader general education curriculum. Both the National Professional Development Center on ASD and the National Autism Center identified Discrete Trial Teaching (DTT) as an EBP for students with ASD. DTT uses small repetitive steps to teach concepts in a planned, controlled, systematic one-to-one format where educators pair positive reinforcement with clear contingencies and repetition to teach a variety of new skills. Computer-simulated environments offer one method of training teachers in the area of EBPs without practicing on actual students. The purpose of this investigation was to determine the effects of a didactic training alone (simulating a traditional professional development), and the effects of adding coaching in a virtual reality environment (i.e., TLE TeachLivE™), on special educators' implementation fidelity with DTT in their classrooms with students with ASD. Five in-service special educators who had previous DTT training but were still not implementing the EBP with fidelity participated in the study. Results suggest the didactic training alone was not sufficient to bring special educators to fidelity of implementation with DTT but after one one-hour session in TLE TeachLivE™, participants were able to implement DTT with fidelity in their own classrooms. Special educators maintained their fidelity of implementation up to eight weeks after the conclusion of the intervention. Therefore, coaching in a virtual reality environment following a didactic training was effective in training special educators to implement an EBP with high levels of fidelity in their own classrooms with students with ASD, demonstrating skill transferability and retention.

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# CHAPTER ONE

# INTRODUCTION

This chapter provides a rationale for training teachers of students with Autism Spectrum Disorder (ASD) to implement an evidence-based practice (EBP), Discrete Trial Teaching (DTT), with fidelity via individualized coaching in a virtual reality environment. First, the definition, prevalence, and comorbidity of ASD are discussed. Next, EBPs in general are defined with a further explanation of DTT as one EBP. Implementation fidelity of EBPs is then explored, followed by a discussion of computer-simulated environments in teacher education. Finally, one example of a computer-simulated environment used in teacher education, TLE TeachLivE™, is described. The chapter concludes with the purpose of the current study, including the proposed research questions.

## Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by impairments in social communication, social interaction, and behavioral skills that range from mild to severe (American Psychiatric Association, 2013). The current prevalence rate of ASD is 1 in 68 children in the United States, a 30% increase since 2012 (Centers for Disease Control and Prevention, 2014). ASD is the fastest growing disability category receiving special education services in schools (Ludlow, Keramidas, & Landers, 2007). The number of school-aged children (ages 6 to 21) receiving special education services under the category of ASD in the United States has increased from 94,000 students in 2001 to just over 455,000 students in 2012 (USDOE, 2013). Not only is the prevalence rate of ASD very high, the disorder is often multifaceted.

ASD rarely presents as a single disability. Of children diagnosed with an ASD, 95.6% are also diagnosed with a second developmental disability (Boulet, Boyle, & Schieve, 2009). Fifty to 70% of all persons with ASD present with an Intellectual Disability (Matson & Shoemaker, 2009). Therefore, students with ASD not only exhibit the primary characteristics of the disability, but also often exhibit secondary characteristics of additional disabilities causing individuals with ASD to have a variable set of unique strengths and needs. As ASD is the most prevalent developmental disorder today and the fastest growing disability category receiving special education services, teachers must be well versed in the implementation of instructional strategies that have repeatedly demonstrated success for students on the spectrum through rigorous research.

## Evidence-Based Practices

Special educators are encouraged by both federal regulation (NCLB, 2002) and professional standards (Council for Exceptional Children, 2009) to use effective interventions and strategies supported by research. In order to be effective, special educators must be knowledgeable about evidence-based instructional strategies that address disability-specific needs in order to provide intensive, explicit instruction within the broader general education curriculum (Brownell, Sindelar, Kiely, & Danielson, 2010) particularly for students who display unique, multifaceted characteristics such as learners with ASD. Evidence-based practices (EBPs) are defined as instructional strategies that have consistently yielded positive effects when experimentally tested through rigorous research (Marder & Fraser, 2012; Simpson, 2005). Unfortunately, not only are many teachers unaware of EBPs, they have not mastered the few they are familiar with to the level that is required to impact student learning (Scheuermann, Webber, Boutot, &

Goodwin, 2003). Two organizations have conducted an analysis of the research in order to identify EBPs for students with ASD. The National Professional Development Center on ASD (NPDC on ASD) identified 27 EBPs (Wong et al., 2014) and the National Autism Center (NAC, 2009) identified 11 established treatments through the National Standards Project. While the NPDC on ASD focused on individual interventions, the NAC clustered individual strategies together into intervention classes (Wong et al., 2014). Twenty of the 27 EBPs identified by the NPDC on ASD overlap with 10 of the established intervention classes identified by the NAC. Discrete Trial Training, also known as Discrete Trial Teaching (DTT) was considered part of the behavioral package by the NAC. Therefore, one of the overlapping EBPs is DTT.

**Discrete Trial Teaching**

DTT uses small repetitive steps to teach concepts in a planned, controlled, systematic one-to-one format where educators pair positive reinforcement with clear contingencies and repetition to teach new skills (Ghezzi, 2007). Each trial has a definitive beginning and end, hence the name, discrete trial (NPDC on ASD, 2010). The four main components of DTT are instruction, student response, reinforcement/correction, and data collection (Heward, 2006). Purposeful planning and execution of antecedents and consequences are important components of DTT (NPDC on ASD, 2010). Data collection is another important component of DTT as it supports teacher's decision making by providing information about skill level, progress, difficulties, skill acquisition, maintenance, and generalization of learned skills (NPDC on ASD, 2010). DTT meets the criteria for an evidence-based practice for early childhood and elementary-aged children across all ability levels (NPDC on ASD, 2010). Research has demonstrated positive effects with DTT in the areas of school-readiness, academic, cognitive, adaptive, communication/language, social, joint attention, and behavioral skills in a variety of settings from self-contained to full inclusion (NPDC on ASD, 2010; Wong et al., 2014). DTT can also be implemented in home or community settings (NPDC on ASD, 2010). Teachers who work with students with ASD not only need the knowledge of EBPs but the capacity to deliver those instructional strategies with fidelity (i.e., high levels of accuracy; Odom, 2009), a critical variable for maximizing student achievement (Kretlow & Bartholomew, 2010).

**Implementation Fidelity**

Teachers who work with students with ASD need to be trained to implement EBPs with fidelity (Scheuermann et al., 2003; Simpson, 2004, 2005). Low and inconsistent levels of fidelity of implementation of EBPs is actually associated with lower gains in student achievement (Kretlow & Bartholomew, 2010). Unfortunately, novice teachers are teaching children with only limited knowledge and skill experience (Dieker, Hynes, Hughes, & Smith, 2008) and practicing teachers typically receive professional development opportunities that are limited in scope and content with no opportunity for practice (Simpson, 2004). Further, Dieker and colleagues (2008) raise the issue of the lack of skill generalization from one setting to another but posit that practicing on students is unethical. Teaching students with strategies that are not yet perfected exposes students to inadequate teaching, which can have a negative effect on increased student achievement, at the least causing the students to make no or only minimal improvements. The strongest link between EBPs and positive student learning outcomes is instruction with fidelity of implementation (Vince-Garland, Vasquez, & Pearl, 2012). Improving teachers' fidelity of implementation of EBPs "is a critical variable for maximizing student achievement" (Kretlow & Bartholomew, 2010, p. 279). Therefore, it is essential to identify a method for training special educators to use EBPs to the highest standards of fidelity and transfer those skills to students who have unique needs without exposing students to less than adequate teaching. One training method that has been recognized as an evidence-based practice for training practitioners is coaching (Parsons, Rollyson, & Reid, 2012).

**Coaching**

Educators recognize that professional development provided in one session where teachers simply hear about the practice with no follow-up support is ineffective in teacher improvement (Knight, 2009; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). In order for teachers to translate research into practice, they require much more support (Knight, 2009; Yoon et al., 2007). The purpose of coaching is to provide support, encouragement, and technical feedback in order to assist teachers in the transference of skills from training to the classroom (Showers, 1982) and translating research into practice (Knight, 2009). Coaching encompasses demonstration, practice, and feedback (Raney & Robbins, 1989) provided by experts in the field (Kretlow & Bartholomew, 2010).

Coaching also integrates components of effective adult learning (Kretlow & Bartholomew, 2010). For adults, engagement in the learning process occurs when the content is related to their current experiences and they are able to play an active participation role (Kretlow & Bartholomew, 2010). The process of coaching relies heavily on teacher experiences as it is first based on observation of the teacher, then feedback is provided based on that observation. Active participation is required in coaching as the teacher practices newly learned skills with the coach prior to executing the procedures with students. Further, the coaching process allows teachers to apply newly learned skills within the context of their own classroom and then receive feedback addressing their individual strengths and needs (Kretlow & Bartholomew, 2010). Technology offers the potential to overcome these barriers. Coaching paired with technology has the potential to address educational concerns such as practicing teaching strategies with actual students.

## Technology in Teacher Education

Technology can address the challenge of finding an effective mechanism to provide essential experiences where educators can refine teaching techniques using a controlled and coordinated environment (Hixon & So, 2009; Vince-Garland, 2012). Technology-based platforms allow teachers to receive immediate feedback regarding their instructional practices without interrupting instruction for students (Scheeler, McKinnon, & Stout, 2012). Practice in virtual environments can decrease the loss of potential student learning time while teachers are perfecting their skills (Andreasen & Haciomeroglu, 2009). Further, the National Council for Accreditation of Teacher Education (NCATE, 2010) stated technology must be incorporated to facilitate ongoing professional learning. One type of technology that can provide feedback and training to teachers is computer-simulated environments.

### Computer-Simulated Environments

Computer-simulated environments provide users with a realistic learning context in which they can interact with and gain insight into a real world process or event through active learning (Cruickshank & Telfer, 1980; Lee, 1999). These environments offer a way for participants to learn through both intrinsic (within teaching) and extrinsic (provided by another individual) feedback. The user's interaction with the environment changes the output, which provides intrinsic feedback to the user. An expert coach provides extrinsic feedback to the user immediately after the session, which is one necessary component to effective use of computer-simulated environments. Virtual reality environments, one form of computer simulation, enable teachers to practice the application of and experiment with learned techniques in a safe, carefully controlled, realistic environment. One virtual reality environment that has demonstrated through research the capacity to prepare teachers in a classroom environment is TLE TeachLivE™ (Myers, Reier, & Lignugaris/Kraft, 2010; Vince-Garland, 2012; Vince-Garland, Vasquez, & Pearl, 2012).

**TLE TeachLivE™**

TLE TeachLivE™ (Teaching and Learning in an Interactive Virtual Environment) is a learning lab designed to provide educators a place to practice teaching with virtual characters (avatars) manipulated by human performers (interactors) in a realistic virtual setting in which interactions occur in real time and can be scripted or spontaneous (Vince-Garland, 2012). TLE TeachLivE™ was developed at the University of Central Florida (UCF) and is currently being used on 42 campuses across the United States, allowing educators to learn new skills and perfect their practice without placing real students at risk during their own learning process (TLE TeachLivE™, 2015). One avatar within TLE TeachLivE™ is a male with ASD who has limited verbal ability and is able to display typical characteristics of ASD such as rocking, flapping, moaning, and not attending (Vince-Garland, 2012). This avatar provides teachers with the opportunity to hone their skills while working with a virtual character who exhibits typical behavioral characteristics of ASD, potentially increasing teachers' skill generalization to real students with ASD. Furthermore, previous research has demonstrated the short training time needed in the virtual lab to reach implementation fidelity, potentially decreasing the loss of student learning time in the classroom (Vince-Garland, 2012). As TLE TeachLivE™ continues to expand across the United States, it has the potential to decrease student's exposure to under-prepared, ineffective teachers, thereby improving teacher practice, which can lead to increased student achievement (Dieker et al., 2008).

## Purpose of the Study

Previous research suggests that teachers can be trained to implement DTT with fidelity using a technology platform such as TLE TeachLivE™ paired with individualized coaching (Myers et al., 2010; Vince-Garland, 2012; Vince-Garland et al., 2012). The purpose of the current study was four fold: (1) to extend previous research to participants who have had training in the use of DTT but continue to demonstrate low levels of fidelity; (2) to demonstrate the effectiveness of using the TLE TeachLivE™ lab in an offsite location; (3) to demonstrate the immediacy of participant skill transference to the classroom; and (4) to determine the effectiveness of variable coaching components. The efficacy of both a didactic training representing a typical professional development and then the addition of coaching in a virtual environment on educator's fidelity of DTT implementation was measured.

### Research Questions

Three research questions were explored in the current study:

1. How does a didactic training effect special educators' implementation of Discrete Trial Teaching (DTT) in their own classroom with students diagnosed with autism spectrum disorders (ASD)?

2. How does coaching in a virtual reality environment effect special educators' implementation of DTT in their own classroom with students diagnosed with ASD?

3. Can the results of these trainings (implementation of DTT with fidelity) be maintained by special educators' in their own classroom with students diagnosed with ASD over time?

# CHAPTER TWO

# LITERATURE REVIEW

This chapter provides an in-depth literature review of Discrete Trial Teaching (DTT), coaching, and the use of computer-simulated environments in teacher preparation. This chapter begins with an overview of DTT, followed by a critical review of several research studies that examined DTT. Next, an overview of coaching is provided, followed by a critical review of five research studies that investigated coaching methods to train special and general educators. Then, a brief introduction defining computer-simulated environments is presented, followed by a discussion of the rationale behind using computer-simulated environments in teacher preparation. Next, an overview of the history of computer simulations in teacher preparation is provided. Then, the potential of using computer-simulated environments in teacher preparation is explored, followed by the implications of its use. Finally, the chapter ends with a description of a specific computer-simulated environment, TLE TeachLivE™, and a critical review of the research studies that used this computer-simulated environment to train educators.

## Discrete Trial Teaching

Discrete Trial Teaching (DTT) has demonstrated significant positive outcomes through rigorous research, making it an evidence-based practice for individuals with ASD (NAC, 2009; Wong et al., 2014). Research has demonstrated positive student outcomes of DTT in the areas of school-readiness, academic, cognitive, adaptive, communication/language, social, joint attention, and behavioral skills (NPDC on ASD, 2010; Wong et al., 2014). In a seminal article, Lovaas (1987) demonstrated the effects of a three-year behavioral intervention project on children with ASD.

Lovaas (1987) investigated the effectiveness of a three-year behavioral intervention project to maximize behavioral treatment gains in children with autism who were less than four years old at the start of the study. Researchers assigned children to one of two groups (both received one-to-one treatment each week that relied heavily on DTT): the intensive-treatment experimental group received more than 40 hours of treatment per week and the minimal treatment control group received 10 hours or less of treatment per week. A second control group was included in the study that was similar to control group 1, but did not receive treatment through the same project. The dependent measures were educational placement and Intelligence Quotient (IQ). In some cases, the participant's diagnosis of autism was withheld in order to control for an educational placement based solely on diagnosis (Lovaas, 1987).

Results indicated that the experimental group made significant gains as compared to both control groups (Lovaas, 1987). The two control groups did not differ during intake or follow-up. The experimental group scored significantly higher on educational placement and IQ at follow-up. Participants in the experimental group gained 30 IQ points on average over participants in the first control group; causing the number of participants who scored in the normal range for intellectual functioning to increase from two to 12 and the number of participants who scored in the moderate-to-severe intellectual functioning range decreased from 10 to three. IQ rates for participants in the two control groups remained stable. In the experimental group, nine children attended a regular first grade classroom and had an IQ in the average to above average range. Eight participants' mean IQ scores were in the mildly retarded range and they attended a first grade classroom for students with aphasia. Only two children were placed in classes for autistic/retarded children whose mean IQ scores fell in the profoundly retarded range (Lovaas, 1987).

Lovaas (1987) cited some limitations. First, the favorable outcomes may have been caused by staff attitudes and expectations, but this was ruled implausible due to two main factors cited by Lovaas (1987): (1) the participants in the second control group had no contact with the project and the two control groups did not differ at follow-up; and (2) the within-subjects analysis demonstrated that at least one treatment component contributed to the experimental group's favorable outcome. Another limitation cited by Lovaas (1987) was that it would be unlikely to replicate the experimental group's treatment program without the extensive knowledge and experience of the researchers. A third limitation was the addition of aversives (a loud "no" or thigh slap) contingent upon high rates of aggression and self-stimulatory behaviors, even though it was used as a last resort (only after planned ignoring, time-out, and in addition to the shaping of more socially acceptable behaviors). Contingent aversives were isolated as a significant variable in the within-subjects analysis, so the positive outcomes would be unlikely without this component. Fourth, it was unknown what the effects of exposure to non-disabled peers were for the group included in the general education classroom. In addition, favorable outcomes would probably not be generalized to older children with autism because it is easier to successfully include two to four year olds in a general education classroom then it is for older students (Lovaas, 1987). Despite these limitations, Lovaas (1987) drew valid conclusions on the effects of an intensive behavioral treatment package with the primary component of DTT on student outcomes.

Not only has research been conducted on the effects of DTT on individuals with ASD, but research has also been conducted on training individuals how to implement DTT.

Koegel, Russo, and Rincover (1977) examined the feasibility of developing reliable, valid criteria for measuring and training 11 special education teachers to use behavior modification procedures with 12 children with autism in a multiple baseline across participants design. Researchers trained special educators to use five categories of behavior modification procedures, one of which was DTT. First, the teachers read a training manual that contained examples of correct and incorrect use of the behavior modification procedures. Next, while the special educator attempted to teach a child with autism a new skill, the trainer provided feedback approximately every five minutes regarding the teacher's performance. If an error occurred, the trainer, either one of the authors or a trained university student, modeled the correct procedure. Trainers kept the feedback brief so interference was minimal, with more extensive feedback provided approximately every 30 minutes. Training took place over five days (five hours per day) or over 10 days (2.5 hours per day), for a total of 25 hours or less. The teacher's behaviors were scored in 30 second intervals as either correct (completed all aspects of the operational definition for all procedures during the interval) or incorrect (did not complete all aspects of the operational definition for any of the trials observed during the interval). Child performance was rated correct, incorrect, prompted, or an approximation of the target behavior for each trial. In addition, observers rated the last 10 trials with either a one, indicating learning occurred as compared to the first 10 trials (i.e., higher percentage correct, fewer prompts, closer approximations), or a zero, indicating no improvement and/or deterioration (Koegel et al., 1977).

Results indicated that it was possible to assess empirically teachers' behavior modification techniques and systematic improvement in the child's behavior only occurred when the teacher used the procedures with a high level of fidelity (Koegel et al., 1977). Ten of the 11 special educators displayed low percentages during baseline. Data demonstrated a drastic shift in level for those 10 teachers at the start of intervention. After training concluded, teacher behavior also generalized to new tasks and new students. During baseline, the children with autism displayed a decrease in correct responding or no improvement. In contrast, after training, children demonstrated improvements in their level of responding during all 26 post-training sessions (Koegel et al., 1977).

Koegel et al. (1977) noted a few limitations in their study. First, the training was a package encompassing modeling, feedback, and training manuals so it was unknown, which part(s) contributed to the results. Second, the authors did not attempt to determine correlations between intermediate levels of teacher proficiency and child responding so it was unknown at what point correct child responding increased (Koegel et al., 1977). Despite these limitations, not only were the authors able to successfully train 11 special educators to implement DTT, but the students with ASD who received DTT also increased their accuracy in responding, demonstrating the occurrence of learning (Koegel et al., 1977).

Sarokoff and Sturmey (2004) examined the efficacy of a behavioral skills training package on staff implementation of DTT in a multiple baseline across participants design. Participants were three special educators who had previous DTT training prior to the study and one three-year-old with ASD. The dependent measure was the percentage correct on 10 DTT components. Prior to baseline, the experimenter gave the special educator a written list of component directions. Then, baseline data were collected while the special educator conducted 10 trials of DTT with the three-year-old with ASD. During training, the experimenter provided the special educator with a written copy of procedures (same as in baseline) and reviewed all components. The experimenter then provided the special educator with a graph of their progress and previous session's data sheet as well as feedback regarding their performance in the previous session. Next, the special educator conducted three trials of DTT with the child. Verbal feedback from the experimenter in the form of positive comments on correct components and corrective feedback on incorrect components was provided immediately afterwards. Then, the experimenter modeled three trials of DTT with the child. These rehearsal and modeling steps were repeated over a period of 10 minutes. Finally, the teacher conducted 10 uninterrupted trials of DTT. Training ceased when the special educator achieved 90% or more correct responses over three consecutive training sessions. Post-training consisted of the special educator conducting 10 trials of DTT with no training (Sarokoff & Sturmey, 2004).

Results indicated large improvements in DTT implementation for all three special educators following the first training session (Sarokoff & Sturmey, 2004). Mean baseline scores were 43%, 49%, and 43%. Mean post-training scores were 97%, 98%, and 99%. Further, special educators sustained their high fidelity scores over time. The researchers (Sarokoff & Sturmey, 2004) discussed one limitation to the study – it was unclear which components were necessary for effective teacher training. Two additional limitations should be noted. First, the researcher was the coach so it was unclear if the effects could be replicated across other coaches. Second, no student data were collected to demonstrate improved student outcomes. Regardless of these limitations, Sarokoff and Sturmey (2004) validated the efficacy of a behavioral skills training package on staff implementation of DTT. The previous studies reviewed the effects of traditional training on staff implementation of DTT. The next two studies further investigated the addition of a technology component to the training.

Eldevik, Ondire, Hughes, Grindle, Randell, and Remington (2013) examined the effects of computer simulation training on in-vivo DTT with 12 novice tutors who were going to be employed full time at a behavior intervention center in the UK. The researchers used a within-subjects pre/post-test design. DTkid is an interactive computer simulation in which the user interacts with a virtual child with autism. Users could operate the software in teaching mode, where the user received real-time feedback of their actions on screen, or in evaluation mode, where the accuracy with which the user presented discrete trials was evaluated. DTkid utilized both object matching and receptive labeling tasks. The authors (Eldevik et al., 2013) used three dependent measures: the Evaluation of Therapeutic Effectiveness (ETE), the Video Observation Test (VOT), and the evaluation mode within DTkid. Researchers used ETE to measure participant competence in the implementation of DTT in-vivo. The VOT required participants to watch a standardized video of a teacher implementing DTT and then rate the teacher's performance as either correct or incorrect, and then report on their confidence levels in their responses. The VOT served as a measure of participant's declarative knowledge of DTT. Participant training involved DTkid in teaching mode. Participants completed two teaching programs, receptive labeling and object matching, for a total of 10 minutes. The simulation required correct performance on a trial before moving to the next training trial (Eldevik et al., 2013).

Improvements in in-vivo teaching between the pre- and post-tests were evaluated using paired sample *t* tests (Eldevik et al., 2013). When average scores were pooled across the three teaching programs (receptive labeling, expressive labeling, and verbal imitation) within in-vivo teaching, significant improvements were found. Significant improvements were also demonstrated for each of the three teaching programs in in-vivo teaching. Pre- and post-tests within DTkid evaluation mode displayed significant improvements. Likewise, data from the VOT also demonstrated significant improvements for both declarative knowledge of DTT and participants' confidence in scoring (Eldevik et al., 2013).

Eldevik et al. (2013) noted some limitations. First, the measure used (ETE) was not standardized or validated. Second, the researchers did not employ a control group who did not receive the intervention due to practical considerations. Therefore, a causal relationship cannot be established between training via DTkid and improvements in in-vivo DTT implementation (Eldevik et al., 2013). An additional limitation should be noted – student data was not included in the study so the effects of staff implementation of DTT on student performance cannot be quantified. However, the results of this study justified further investigation into computer simulation training to increase staff's implementation of DTT.

Nosik, Williams, Garrido, and Lee (2013) compared behavior skills training to computer-based instruction for teaching six direct care staff to implement DTT with an adult with autism using a multiple baseline across participants design. The accuracy of the participant's behavior based on the critical trainer skills checklist was the dependent measure. The checklist encompassed ten components of DTT from having materials ready to providing an inter-interval break. Participants were required to achieve 100% accuracy across 10 consecutive trials during role-playing practice sessions with a research assistant. The behavior skills training (BST) took place in one day; the training time varied from 68 to 92 minutes across participants, as they were required to reach a 90% criterion prior to training completion. BST encompassed a PowerPoint presentation including instructions on the 10 steps of DTT, modeling of DTT between the experimenter and a trained research assistant, and general feedback during the rehearsal/practice component. The computer-based training package involved instructions with video modeling, 20 multiple-choice knowledge-based questions, and several scenarios depicting correct and incorrect procedures in which the participants rated and then were shown the correct answers. A rehearsal component was not included and the participants were not allowed to ask questions (Nosik et al., 2013).

Results indicated that the behavioral skills training package was more effective than computer-based instruction in improving participants' accuracy of DTT implementation (Nosik et al., 2013). Baseline rates for the BST group were below 40% and improved to a mean of 87% on the first trial following training. Six-week maintenance probes were all above 80% for the BST group. Baseline rates for the computer-based instruction group were also below 40% but only improved to a mean of 65% for the first post-training trial. Although the computer-based instruction group's average scores improved after training, they remained lower than the BST group. Six-week probe data displayed decreases in accuracy of DTT implementation for the computer-based instruction group (Nosik et al., 2013). The researchers noted one limitation. First, no client data were included to demonstrate improved outcomes for those receiving DTT instruction as state statutes prohibited adult wards to publish client data for research purposes. Despite this limitation, the authors' conclusions remain valid. Further research should be conducted in order to determine the effectiveness of behavior skills training used in conjunction with computer-based instruction. As the behavior skills training package in this study (Nosik et al., 2013) involved both modeling and feedback, two components of coaching, further research should be done to determine the effectiveness of coaching on DTT implementation.

## Coaching

In a review of research, Knight (2009) identified nine components of effective coaching which were commonly used across several types of coaching. First, coaching focused on professional practice. In other words, the purpose of coaching was to improve student's education by improving the teaching methods of educators. Second, teachers could immediately apply the methods to their lessons and classrooms. Third, coaching was intensive and provided on-going differentiated support in order to meet the unique needs of teachers in a one-to-one format. In addition, coaching could last several days, weeks, and even months. Fourth, coaches were collaborators in an equal partnership with teachers. Fifth, coaches attempted to enable reflective dialogue with teachers. Sixth, coaches were non-evaluative: even though coaches observed teachers, their discussions were nonjudgmental. Seventh, coaching was confidential: teachers were able to discuss their strengths and concerns openly. Finally, coaching required excellent communication skills wherein coaches articulated clear messages and listened respectfully in an energizing, encouraging, practical, and honest manner. These eight components made coaching an effective practice (Knight, 2009).

Knight (2009) also identified seven conditions, which were necessary for coaching to be successful. These conditions repeatedly surfaced through a Kansas Coaching Project that took place over three years. First, coaching needed to be focused and continuous. In other words, districts needed to "have a sustained focus on a few high-leverage strategies" (Knight, 2009, p.19) as teachers could easily become overwhelmed when districts attempted to implement too many practices, which in turn decreased teachers' enthusiasm for any change. Second, a learning-friendly culture was essential because when teachers felt respected and were free to take risks they were more likely to experiment and learn. A teacher's desire to learn can be diminished dramatically when they are punished more than praised and feel they are under constant scrutiny. A third essential for successful coaching was principal support. Fourth, coaches had to have the clear role of a teacher's peer. Coaches should not perform administrative tasks that are evaluative; instead, they should provide the necessary support for professional learning to take place. Fifth, the coaching relationship should take place via teacher choice. In other words, principals should provide teachers with other options to improve their practice such as reading articles or attending conferences as the teacher may perceive the coach as a punishment if their relationship is not by choice. Sixth, according to Knight (2009) "the single most powerful way to increase the effectiveness of coaches is to ensure that they have sufficient time for coaching" (p. 19). Finally, continuous learning on the coach's part was crucial, as the coach needed to have an in-depth understanding of both the practices/content knowledge they were teaching and the practices/communication skills that were required for effective coaching. These seven conditions made coaching a success (Knight, 2009).

Feedback has been identified as an effective component of coaching in the literature (Knight, 2009; Kretlow & Bartholomew, 2010). Following an observation, coaches provide teachers with specific feedback based on observation data and self-evaluation (Kretlow & Bartholomew, 2010). Technical feedback and general evaluation differ in several ways (Showers, 1982). Technical feedback does not imply judgment about overall teaching quality; instead, it only entails information about the teacher's performance of the targeted skills or strategies (Showers, 1982). Coaches discuss omissions, material arrangement, and the cohesiveness of the teaching strategy to ensure that the teacher's growth continues as classroom practice (Showers, 1982). Kretlow and Bartholomew (2010) reviewed research to determine other effective components of coaching.

Kretlow and Bartholomew (2010) examined studies that focused on the effects of coaching on teacher's implementation of evidence-based practices that were published from 1989 to 2009. Thirteen studies fit the inclusion criteria (see Kretlow & Bartholomew [2010] for a complete list of inclusion criteria). Studies used two primary types of coaching: side-by-side coaching and supervisory coaching. Side-by-side coaching generally began with an observation by an expert or skilled peer, followed by the co-teaching of an in-class lesson where the coach modeled targeted teaching skills and afforded opportunities for teacher practice while providing support and error correction. Supervisory coaching entailed an expert or skilled peer conducting an observation and then providing constructive feedback in a structured format. While some of the studies used only one coaching style, several studies used both styles in combination (Kretlow & Bartholomew, 2010).

All 13 studies included multiple observations followed by individualized feedback based on observational data (Kretlow & Bartholomew, 2010). Feedback often encompassed a direct statement of strengths as well as opportunities for improvement (Kretlow & Bartholomew, 2010). After providing feedback, coaches often modeled specific instructional skills and then provided the teacher an immediate opportunity to practice the skill. The observational data allowed for a measure of change in teacher performance. Capturing a set of discrete skills and calculating the overall percentage of accuracy provides a measure of instructional fidelity (Kretlow & Bartholomew, 2010). A majority of the studies identified a few key components of coaching: the presentation of new skills (which included modeling and systematic prompting), guided practice (which included multiple response opportunities), and active engagement. The results of the review suggested, "coaching is a promising practice for promoting high fidelity of evidence-based practices from training settings to real classroom settings" (Kretlow & Bartholomew, 2010, p. 293). Further, data across the 13 studies suggested that group instruction, such as in-service professional development and college courses, are typically not sufficient to produce instructional change in the classroom. In addition, several of the studies demonstrated substantial improvements in fidelity of implementation of evidence-based practices after just one or two coaching sessions. Therefore, preservice and in-service training should include coaching in order to train teachers to implement evidence-based practices with fidelity in their classrooms (Kretlow & Bartholomew, 2010).

Miller, Harris, and Watanabe (1991) examined the effectiveness of professional coaching on increasing positive teacher behaviors and decreasing negative teacher behaviors through a multiple baseline across participants design. There were six special education teachers enrolled in the study who all had previous teaching experience. The researchers used the Florida Performance Measurement System (FPMS) to record effective and ineffective teacher behaviors during observations. Teachers received two coaching sessions, in pairs, during the intervention phase (Miller et al., 1991).

The study consisted of baseline, treatment, and post-treatment phases (Miller et al., 1991). Three observers (one of which was a program supervisor) recorded baseline data during 15-minute observations in which they scored the teacher using the FPMS. The researchers did not share the FPMS with the teachers nor did they provide feedback during the baseline phase. During the treatment phase, university supervisors used the FPMS during 15-minute observations and then conducted two coaching sessions with pairs of teachers. In the post-treatment phase, follow-up observations were conducted at least three months after the last coaching session. The researchers did not review the FPMS with the teachers prior to the visit, but the teachers knew when the observers were coming to their classroom. The post-treatment phase represented teacher retention and generalization of learned behavior skills (Miller et al., 1991).

Coaching sessions involved six components and were approximately 30 minutes in length (Miller et al., 1991). First, the teachers identified what they liked about the lesson. Next, the teachers identified what they would change in the future. Third, the coaches shared the observation data with the teachers. Fourth, the teachers determined which behaviors they wanted to increase, decrease, and maintain, based on the data provided. Next, the teachers reviewed the strategies (e.g., verbal cues, gestures, notes) for coaching one another on the target behaviors. Finally, the coaches provided teachers with copies of their coaching forms. The second coaching session occurred about one week after the first, in which the same six components were used (Miller et al., 1991).

During baseline, paired teachers displayed similar trends in teaching behaviors, but the trends differed across each teacher pair (Miller et al., 1991). However, all teachers scored higher in their use of effective behaviors as compared to ineffective behaviors. The first teacher pair increased their use of both effective and ineffective behaviors prior to their coaching session. The second teacher pair inconsistently used both effective and ineffective teaching behavior prior to coaching and the third teacher pair increased their use of effective behaviors during baseline, but their ineffective behaviors fluctuated greatly (Miller et al., 1991).

All teachers identified several skills to work on during the first coaching session (Miller et al., 1991). Two of the skills teachers wanted to increase were consistent across all teacher pairs: use of specific academic praise and use of higher level questioning that required student analysis. In addition, all teachers wanted to decrease their use of general non-specific praise. University supervisors documented the teacher's progress on increasing and decreasing these skills during the next observation (Miller et al., 1991).

Only two of the three teacher pairs displayed marked improvement after the first coaching session. The first two teacher pairs increased their use of specific academic praise and higher-level questioning, among other behaviors identified as effective. Similarly, the first two teacher pairs decreased their use of general nonspecific praise, among other behaviors identified as ineffective. However, the third teacher pair did not demonstrate marked improvement after the first coaching session in either increased use of effective behaviors or decreased use of ineffective behaviors (Miller et al., 1991).

After the second coaching sessions, teachers experienced different results (Miller et al., 1991). The first team of teachers increased their use of effective behaviors, but only temporarily. One teacher on the second team of teachers maintained their performance, while the other teacher improved. The third team displayed a dramatic increase in effective teaching behaviors. In addition, all teachers maintained their decreased use of ineffective teaching behaviors from the first coaching session (Miller et al., 1991).

In the post-treatment phase, teachers continued to use effective behaviors as identified by the FPMS (Miller et al., 1991). However, only three of the six teachers increased their use of effective teaching behaviors, while two of the teachers regressed to their highest scores in baseline. Although the sixth teacher's effective behavior decreased from the second coaching session to follow-up, effective teacher behaviors remained higher than baseline. Use of ineffective teacher behaviors remained low for all six teachers. The most common ineffective teacher behavior observed was general non-specific praise statements. The authors concluded that the results of the study suggested that two coaching sessions in a five-week period were effective in improving and maintaining teacher performance three months later as measured by the FPMS (Miller et al., 1991).

Although the authors' stated the study results suggested coaching sessions were effective for both improving and maintaining teacher behaviors, only half of the teachers maintained their increased positive teacher behaviors during the three month follow-up (Miller et al., 1991). While it is agreed that the coaching sessions resulted in immediate improvement, one may question the effectiveness of the two coaching sessions to maintain teacher performance over time. This may be due to the limited number of coaching sessions (two) provided to the participants. It may be the case that more coaching sessions are required for teachers to maintain their effective teaching behaviors over time. It is unclear whether the coaching sessions should be extended for a longer period of time, or more coaching sessions should be provided during the five-week intervention period. Miller et al. (1991) only cited one limitation: teacher behaviors varied daily, most plausibly due to the variability of instruction, which limited the number of opportunities to exhibit some of the behaviors. The authors (Miller et al., 1991) stated that it may be beneficial to limit the type of teaching tasks in future research. It may also be beneficial to record the number of opportunities presented and then divide the number of observed behaviors by the number of opportunities to get a percentage that can be compared across teaching tasks. The advancement of technology in data collection today makes this solution more plausible than it may have been in 1991.

Kretlow, Wood, and Cooke (2009) investigated the effects of in-service support plus coaching on three kindergarten teacher's accurate delivery of a combination of three whole-class instructional strategies: model-lead-test (MLT; teachers model the correct response, teachers say the correct response with the students, and then students say the correct response without the teacher), choral responding, and response cards. The dependent measure was the percentage of group instructional units implemented correctly during 10-minute segments of calendar math lessons. Correct group instructional units consisted of either a three-term contingency or a series of three-term contingencies beginning with an antecedent provided correctly by the teacher and ending with an independent and correct unison student response (Kretlow et al., 2009).

Intervention consisted of a three-hour group in-service training followed by coaching (Kretlow et al., 2009). The in-service training was delivered via a PowerPoint presentation and provided teachers with an overview of the three whole-class instructional strategies including a rationale for increasing group responding, an explanation of the critical features, and live and video demonstrations. The in-service also provided teachers with the opportunity to practice their newly learned strategies in pairs with feedback provided by the researcher. Coaching encompassed three components: one preconference/planning meeting, one side-by-side coaching session, and one post-conference meeting. The pre-conference/planning meeting lasted 15 to 20 minutes in which the researcher gave the teacher specific feedback on their strengths and opportunities for improvement in MLT, and unison responding, via verbal or written student response cards. The researcher and teacher then co-planned the lesson for in-class coaching. Next, the researcher modeled how to select strategies for the target skills, asked guiding questions to support the teacher as they selected the strategies, and provided feedback and correction. The in-class coaching session lasted 30 to 45 minutes during a regularly scheduled math lesson using the side-by-side coaching model. The researcher modeled each strategy across the math skills, and then prompted the teacher to try the same strategy, using specific praise and non-evaluative error correction. Next, the researcher provided the teacher with another opportunity to implement the group instructional unit. The post-conference occurred five sessions after the initial coaching session in which the researcher followed up on the skills coached in the first session by providing verbal feedback and corrections, and answering the teacher’s questions. Procedural fidelity data were collected by one of the school’s special education teachers using a checklist of prescribed steps and was rated at 95.8% across the interventions (Kretlow et al., 2009).

Results indicated that the teachers improved after the in-service training and then again after the addition of coaching (Kretlow et al., 2009). After all three teachers demonstrated low levels of group instructional use in baseline, improvements were demonstrated after receipt of in-service training across all three teachers. However, the researchers could not establish a causal relationship due to all teachers receiving the in-service training simultaneously. In addition, although all three teachers made improvements, the use of strategies remained variable and no teacher exceeded 80% correct. The researchers did demonstrate experimental control when all three teachers made additional gains following coaching, as a staggered introduction was used (Kretlow et al., 2009). After coaching, all three teachers exhibited less variability and two of the three teachers demonstrated consistent improvements. Therefore, the researchers concluded that individual coaching was an “added benefit to group in-service training” (Kretlow et al., 2009, p.242).

The researchers (Kretlow et al., 2009) discussed three limitations in their study. First, student outcome data were not collected in order to determine the impact of teacher performance. Second, the results were limited to teachers who already used several of the intervention strategies during Direct Instruction in other areas (e.g., reading). Third, reliability ratios were low in the beginning of the study when unanticipated teacher patterns were not yet resolved. Fourth, the impact of audio recording on teacher’s use of the strategies was unknown (Kretlow et al., 2009). An additional limitation should be noted: one of the researchers provided the coaching so it is unknown if results could be replicated with a different expert coach. Despite these limitations, this study demonstrated in-service plus coaching can increase teacher's accurate use of MLT, choral responding, and student response cards (Kretlow et al., 2009).

Similar to the previous study, Kretlow, Cooke, and Wood (2012) examined the effects of in-service and coaching on three first grade teachers' accurate delivery of three research-based strategies during math and then their ability to generalize their implementation fidelity to different math areas. The dependent measures were the percentage of group instructional units implemented correctly during 10-minute segments of calendar math lessons (trained session) and numeracy and problem solving lessons (untrained sessions/generalization). Group instructional units consisted of the whole-class strategies of model-lead-test (MLT), systematic error correction (immediately after students made an error, teacher provides MLT, model-test, or lead-test), and unison responding (i.e., choral responding and response cards; Kretlow et al., 2012).

Intervention consisted of a three-hour in-service followed by individual coaching in a staggered multiple baseline design in the three research-based strategies: MLT, systematic error correction, and unison responding (Kretlow et al., 2012). Coaching consisted of an individual pre-conference, in-class coaching session, and then an individual post-conference. The preconference and in-class coaching sessions followed the same format as described in the previous study by Kretlow et al. (2009). The post-conference lasted 15 to 20 minutes and consisted of the researcher providing specific feedback on the teacher's strengths and opportunities for improvement, modeling the strategies if necessary, and providing answers to teacher questions. Procedural fidelity data were collected by an observer using a checklist of prescribed steps and was rated at 96.2% across the interventions (Kretlow et al., 2012).

Results indicated that all three teachers increased their number of correct group instructional units after the in-service (Kretlow et al., 2012). Each teacher's implementation of the three research-based strategies increased again immediately after coaching, demonstrating a second change in level and a substantial decrease in variability. Untrained/generalization sessions followed the same pattern. Results indicated a causal relationship between the two-level training and increased use of MLT, systematic error correction, and unison responding (Kretlow et al., 2012).

The researchers (Kretlow et al., 2012) cited a few limitations. Similar to the previous study (Kretlow et al., 2009), researchers did not collect student data in order to determine the impact of teacher performance. Second, variations in MLT for error correction between teachers was not examined. Third, the strategies in the study only pertained to instructional delivery, not content design; as the teachers did not use the structured program with consistency. Finally, the study only involved one coaching session, which may have resulted in decreased teacher accuracy both immediately after the session and sustained accuracy (Kretlow et al., 2012). An additional limitation that should be noted is that the experimenter was the coach so it is unknown whether results could be replicated with a different expert coach. This study replicated the results of the researcher's previous study (Kretlow et al., 2009) and then extended those results by demonstrating sustained accuracy once the coaching sessions were completed.

Suhrheinrich (2011) examined the effects of a six-hour group workshop training on special educator's implementation of Pivotal Response Training (PRT) and then the further effects of coaching on PRT implementation. Two groups of ten special educators were included in the study; one group was self-selected and the other group was district selected. The district-selected group was required to attend the group workshop training as part of their regularly scheduled district professional development. The dependent measure was the teacher's fidelity of implementation of seven PRT components; mastery criteria were set at 80% correct implementation. Observers scored PRT components as either correct or incorrect. The six-hour group workshop training encompassed two hours of didactic instruction, one hour of video modeling, one hour of in-vivo modeling with a child with autism, trainer feedback on how to improve implementation, and a one hour discussion of implementation techniques and questions. Coaching began approximately one week after the workshop training and occurred one time per week. Coaching began with a 10-minute observation in which the coach assessed the teacher's implementation fidelity. Next, the coach provided feedback regarding the components implemented well and components needing improvement. The coach made suggestions and modeled new procedures. Coaching sessions continued until the teacher reached 80% implementation fidelity criteria and ranged from one to four sessions (Suhrheinrich, 2011).

Results indicated that the training sequence was effective in improving teacher's PRT implementation (Suhrheinrich, 2011). A significant effect of the group workshop on PRT implementation was demonstrated using a within-subjects, repeated measure ANOVA. After the group workshop, three out of 20 teachers demonstrated mastery of all PRT components. After the first coaching session, six additional teachers exhibited mastery of all PRT components and two additional teachers (55% total) mastered all of the components after the second coaching session (Suhrheinrich, 2011). The two groups of teachers differed in their correct use of PRT components in baseline with the self-selected group demonstrating a higher percentage of correctly implemented components.

Suhrheinrich (2011) concluded that the results validated the effectiveness of coaching after initial exposure to new intervention strategies. The researcher noted several limitations. First, the study consisted of a small sample size. Although the only significant difference between the two groups was the self-reported time spent reading educational literature, the self-selected group of teachers appeared to have more education, experience, and autism-specific training. Second, the researcher conducted all training (Suhrheinrich, 2011); although inter-rater reliability data were collected, procedural fidelity data were not. Further, it is unknown whether the effects would be the same if the experimenter/expert was removed or if the results could be replicated with a different expert coach. Third, observations were only 10-minutes in length, representing a small sample of a teacher's PRT implementation (Suhrheinrich, 2011). Despite these limitations, the researcher's conclusions were valid.

Bethune and Wood (2013) investigated the effects of coaching on four special educator's implementation of function-based interventions with students with severe disabilities. The first dependent measure was the percentage of accuracy of implementation of the function-based intervention on a procedural fidelity checklist. The checklist was standardized to the use of function-based interventions but tailored to each student's function of behavior and needs. The second dependent variable measured student's target challenging behavior. The third dependent variable measured student's replacement behavior. Data for all three measures were taken during probe sessions. Procedural fidelity data were collected across 50% of sessions to ensure coaching was implemented as designed. Fidelity data averaged 100% accuracy. A delayed multiple baseline across participants was used for teachers and a multiple baseline across participants design was used for students (Bethune & Wood, 2013).

Training consisted of a group in-service followed by coaching (Bethune & Wood, 2013). First, teachers attended a six-hour group in-service prior to the baseline phase. The researcher provided training on the development and implementation of Functional Behavior Assessments (FBAs) via a PowerPoint presentation. Next, the researcher worked with the teachers to complete an FBA and then develop function-based interventions for their students. The coaching intervention consisted of a pre-observation meeting, a side-by-side coaching session that occurred as the teacher worked with the student on the target skill, and a post-coaching feedback meeting. The pre-observation meeting lasted five to 10 minutes and consisted of the researcher providing the teacher with specific instructions on how to implement the function-based intervention. The 10-minute coaching session encompassed the researcher modeling how to implement the intervention and then providing immediate feedback on the teacher's performance. Post-coaching generally lasted less than five minutes where the researcher reviewed the teacher's progress, highlighting accurate steps and reviewing steps the teacher implemented incorrectly. Data were not collected during the coaching intervention, but rather during an observation immediately afterwards. Only three of the four teachers participated in coaching, as the fourth teacher's baseline rates were high and stable (Bethune & Wood, 2013).

Results indicated a causal relationship between coaching and an increase in teachers' implementation accuracy of function-based interventions (Bethune & Wood, 2013). A drastic change in level was observed between baseline and coaching for the three teachers. Challenging behavior rates remained low for students following teacher coaching. The authors noted several limitations. First, the experimenter was part of the entire intervention so it is unknown whether the effects would be the same if the experimenter/expert was removed. Second, it is unknown if results could be replicated with a different expert coach. Third, long intervals were used for partial and whole interval recording of student behaviors, which could lead to a misrepresentation of behavioral occurrences. Fourth, it is unclear what percentage of accuracy teachers must implement function-based behavior interventions in order to obtain consistent results (Bethune & Wood, 2013). However, despite these limitations the researcher made valid conclusions. These studies demonstrated that coaching could assist both general and special education teachers in the transference of skills from training to the classroom. However, by adding the use of computer simulation to the coaching component, educators may not need to practice their skills with actual students.

## Computer Simulation in Teacher Preparation

### Introduction

In 1969, Cruickshank discussed the use of simulation in teacher preparation as a developing phenomenon. However, since then, the widespread use of computer simulation in teacher education has not occurred. Following recent National Council for Accreditation of Teacher Education (NCATE) recommendations, teacher educators today are looking to technology (Hixon & So, 2009) to overcome the challenge of finding an effective mechanism to provide essential learning experiences to refine teaching techniques in a controlled and coordinated environment (Vince-Garland, 2012). Dieker and colleagues (2014) advised that teacher preparation adapt and evolve in order to take advantage of the potential of technology (Dieker, Rodriguez, Lignugaris/Kraft, Hynes, & Hughes, 2014). Computer simulations are one way teacher educators can augment the field of teacher preparation (Dieker et al., 2014), although in the field of teacher education, current literature on simulation and training is limited (Clarke, 2013). Technology is advancing at an accelerated rate, making the use of computer simulation to train educators more affordable and accessible in the field as institutions can access pre-developed virtual reality environments through the internet (e.g., TLE TeachLivE™).

Computer simulation provides users with a realistic learning context in which they can interact with and gain insight into a real world process or event through active learning (Cruickshank & Telfer, 1980; Lee, 1999). Two key features define computer simulation. First, a computer model of either a real or a theoretical system contains information on the system's behavior (Thomas & Hooper, 1991; Thomas & Milligan, 2004). Second, experimentation can occur as the output depends on the user's input (Thomas & Hooper, 1991; Thomas & Milligan, 2004). Virtual reality environments, one form of computer simulation, enable teachers to practice the application of and experiment with learned techniques in a safe, carefully controlled, realistic environment. Although current literature on the use of computer simulation in teacher preparation is limited (Clarke, 2013), computer-simulated environments have a long history in the field of teacher preparation.

**Rationale**

Well-constructed computer-simulated environments provide three key factors that are missing from real-life experiences. First, computer simulations can encompass carefully designed scenarios and situations created to target key learning points, which provides the opportunity for accelerated learning by ensuring that the user encounters specific situations (Cruickshank, 1969; Guralnick & Levy, 2009). Second, guidance and feedback are easily provided immediately, unlike real-life experiences where users can often miss key learning points (Guralnick & Levy, 2009) in the absence of reflection. As the user's input affects the output and in turn the user's experience of simulation (Cruickshank, 1969) learning is enabled across domains and skill transfer increases (Hayes, Straub, Dieker, Hughes, & Hynes, 2013). Third, by designing specific contexts, users gain access to relevant expertise that can be missed in real-life situations (Cruickshank, 1969; Guralnick & Levy, 2009). For example, a computer-simulated environment can address a wide-range of possible student behaviors that may not be manifested in a student teaching experience. For example, the practicing teacher often only has their supervising teacher as a model in reacting to student behavior and they may not demonstrate the best reactive solution (Strang, Kauffman, Badt, Murphy, & Loper, 1987). Further, the student teaching experience also typically occurs near the end of a student's academic program and often does not correlate with the student's prior pedagogical training (Strang et al., 1987). Computer-simulated environments provide a training experience that addresses these three key factors that can often be missed in real-life experiences: targeted scenarios/situations, guidance/feedback, and a plethora of student behaviors.

Computer-simulated environments have the potential to be an effective learning tool as they allow learners to practice skills in a safe, realistic environment that is free of the real-life consequences of mistakes (Cruickshank, 1969; Girod & Girod, 2008; Guralnick & Levy, 2009). They allow teachers to practice instructional strategies, teaching concepts, and classroom management without placing real students at risk (Dieker et al., 2014; Girod & Girod, 2008). In addition, computer-simulated environments allow teachers to receive feedback regarding their instructional practices without the interruption to student learning (Scheeler et al., 2012). Therefore, practice in computer-simulated environments can decrease the loss of potential student learning time while teachers are perfecting their skills (Andreasen & Haciomeroglu, 2009).

There is disagreement among teacher preparation professionals regarding the success of the student teaching experience. In 1969, Cruickshank discussed the continual questioning of teacher educators regarding the impact of student teaching on preservice teachers, with specific concern to the variety of exposure and freedom required to develop one's own teaching and problem solving skills. The possibility exists that student teachers merely mimic the behavior of their mentor teacher, only to find later in their first year of teaching that those behaviors are not only unnatural for them, but they do not work as well in a classroom that is not first conditioned by the supervising teacher (Cruickshank, 1969). One attempt at overcoming this barrier has been the increase to two student teaching internships with different mentor teachers. However, in 2014, Dieker and colleagues continued to express concern, stating their opinion that typical learning environments in the field of teacher preparation such as college classrooms, observations of other's teaching, and student teaching in actual classrooms have not been shown to impact teaching skills effectively, that in turn result in increased student achievement, the field's ultimate goal. In addition, Girod and Girod (2008) state that it is unfortunate that research findings from the analyses of student teaching benefits do not support their value, as they do not meet the pre-service teachers' needs of becoming independent professionals. The complexity of K to 12 classrooms does not afford pre-service teachers with the opportunity to have a meaningful student teaching experience; pre-service teachers instead need an appropriately complex experience that allows them to concentrate on critical skills without becoming overwhelmed (Girod & Girod, 2008).

Traditional student teaching experiences do not provide future educators with the opportunity to reflect on their performance and then make a second attempt in the same situation. In order for teaching practice to be effective, teachers need to be able to repeat practices so they can learn from the consequences of their actions and adjust their teaching accordingly, receive feedback, and practice teaching in a safe environment so their experimentation does not harm actual students (Girod & Girod, 2008). Additionally, these pre-service experiences do not provide exposure to the plethora of possible teaching situations that a teacher may encounter in real classrooms (e.g., misbehaviors, errors, characteristics, misconceptions; Cruickshank, 1969; Dieker et al., 2014). Computer-simulated environments can provide teachers with a classroom of students of various ages, cultures, backgrounds, abilities, and behaviors, (Hayes et al., 2013) increasing teachers' experience with the wide range of students they will encounter in real classrooms. Thus, a critical review of the history of computer-simulated environments in teacher preparation is warranted.

## History

The use of instructional simulations in teacher preparation dates back to 1865. The first reference to simulation in teacher preparation occurred in 1865 when Edwards, the second President of Illinois State Normal University from 1862 to 1876 (Richard Edwards Presidential Papers, 2014), described the preparation of teachers in normal schools in the United States (Cruickshank, 1988). Edwards stated that classes of normal students would assume a child's character, receive instruction, and answer questions as a child would. Years later, in 1961, Kersh, an educational psychologist at the Teaching Research Laboratory of the Oregon State System of Higher Education (American Association of Colleges for Teacher Education, 1968), was possibly the first to create and test a complex classroom simulation for use with pre-service teachers (Cruickshank, 1988). A projection screen placed 22 students in front of a student teacher with a depiction of a classroom problem; then, one of two possible consequences was displayed in reaction to the student teacher's response (Cruickshank, 1988). One of the next documented computer-based simulations would not occur for over a decade later.

In 1973, Flake reported using a computer simulation to teach questioning behaviors to both experienced math teachers and pre-service teachers in a methods course. Student responses provided intrinsic, or embedded, feedback during the simulation. Additional feedback was given to student teachers immediately after the session on both their own questioning behaviors and student performance. Twenty-two out of the 25 students increased their level of student questioning, 19 increased modeling behaviors of problem-solving strategies, 24 reported a positive attitude regarding their experience, and 23 reported that they learned a lot from the simulated lesson (Flake, 1973). Therefore, the computer simulation used in this study appeared to be effective across several domains.

Low-tech, audio-visual based simulation characterized the early period of simulation use, which then shifted to mostly computer-based simulation in the 1980's (Cruickshank, 1988). In 1981, Dekkers and Donatti conducted a meta-analysis of 93 empirical research studies on the use of simulation as an instructional strategy. Studies were classified by their purpose, either cognitive development/ retention or attitude formation. Despite citing ten studies in the introduction that have demonstrated the benefits of simulation, the authors concluded that instructional simulation was more effective than lecturing for attitude formation only, not for cognitive development or retention (Dekkers & Donatti, 1981).

In contrast, Bredemeier and Greenblat (1981) conducted a synthesis of findings on the educational effectiveness of simulation games and found that retention of learned material was greater with simulation gaming as compared to conventional teaching methods. Dekkers and Donatti (1981) may have masked the effects of simulation on retention of knowledge by combining it with studies on its effect on cognitive development. Furthermore, Dekkers and Donatti included both computer and non-computer instructional simulations in their meta-analysis but did not denote which studies involved computer simulations, nor did they provide a list of the articles used in the meta-analysis. Therefore, it is possible that had the studies been broken down into computer-based and non-computer-based, the results would have differed. Unfortunately, Bredemeier and Greenblat (1981) also did not denote which studies were computer-based and which were not, but all of the studies described in detail included computer-based studies, so it is unknown whether non-computer-based studies were even included in the synthesis of their findings.

In 1983, Lloyd and Idol-Maestas reported on the effects of a computer simulation developed by the first author for a Methods in Learning and Behavior Disorders course at Wichita State University. Forty-seven experienced general and special education teachers participated in conducting a curriculum-based measurement for reading, identifying reading strategies, and then determining if those strategies were successful for the students. Ninety-eight percent of the participants agreed that the decision-making process enhanced their understanding of concepts previously taught in class and 79% felt more confident about using the reading strategies in their own classrooms. All participants preferred using the computer simulation to a traditional paper-and-pencil exam. The majority of participants reported they liked the immediate feedback they received after participating in the simulation and most remarked on how fun it was to experience (Lloyd & Idol-Maestas, 1983). Both Lloyd and Idol-Maestas (1983) and Flake (1973) reported beneficial results with using computer simulation to teach teachers (experienced and pre-service) math and reading strategies. In both studies, educators provided the participants with immediate feedback regarding their performance and the majority of students reported they enjoyed the experience.

During the 1980’s and 1990’s, faculty at the University of Virginia’s Curry School of Education developed a series of computer-based simulations to assist pre-service teachers in the application of pedagogical theory learned in lectures to teaching practices (Strang & Clark, 2003). In 1987, Strang and colleagues examined behavior management skills of both experienced teachers and inexperienced education students.

The computer simulation used student's names on the screen to represent students in a classroom. The participant spoke into a microphone to a computer operator who translated their speech into a code the computer could read. Participants received feedback in one of two ways: intra-session changes in pupil behavior (intrinsic feedback) or post-session feedback (extrinsic feedback). In intra-session changes in pupil behavior, the teacher's verbal behavior effected student behavior, which provided feedback to the participants. In the post-session feedback to the participant, researchers provided the participants with computer-generated printouts that displayed the participant-student interactions for the session (Strang et al., 1987). Researchers divided the participants into two groups: high feedback and low feedback. Researchers gave immediate feedback to the high feedback group following the baseline and first training session. The researchers only gave immediate feedback to the low feedback group following the first training session (Strang et al., 1987).

The results of the study were promising (Strang et al., 1987). At baseline, behavior management skills differed significantly between the experienced teachers and the inexperienced education students. After two 20-minute simulation sessions, inexperienced education students demonstrated significant gains in their behavior management skills and there was no longer a significant difference between the two groups. Further, the inexperienced education students maintained those gains over a three-month period. There were no significant differences between the two participant groups, high feedback and low feedback (Strang et al., 1987). Therefore, the participants acquired the target skills at a fast rate and then maintained those skills over time. The similarities between the two groups at the end of the study (high feedback and low feedback) may have been due to the significant improvement in scores after only the first session. In other words, the participants may have only required feedback after the first session to improve their overall scores. Again, research suggests that immediate feedback and reinforcement in the form of correct student answers contributes to positive results when using computer simulation.

Strang, Landrum, and Lynch (1989) criticized many previous computer-based simulations due to the requirement of users to enter codes into a keyboard, a behavior that is far from typical of teacher-student interactions. According to Strang et al. (1989), Strang and Loper designed simulations that allowed the user to engage in conversation with avatars that were capable of responding via computer-synthesized speech. Four attributes contributed to the realism of the simulation with respect to student responding: variety (e.g., yes/no responses, day dreaming, wandering, noise making, response to physical proximity and touch), immediacy, authenticity (e.g., accurate second attempts by the students only occurred after the teacher provided assistance), and multiplicity (e.g., different students engaged in various behaviors simultaneously). In addition, the simulation provided three powerful learning principles: practice (e.g. multiple teaching attempts), reinforcement (e.g., student compliance and accurate responses after assistance), and feedback (e.g., confirming correct responses, identifying errors, providing remediation; Strang et al., 1989).

Researchers used this simulation to teach 61 pre-service teachers skill acquisition in the areas of student misspelling interventions and behavior management across three sessions (Strang et al., 1989). The pre-service teachers increased their use of effective spelling interventions and behavior management strategies and decreased their use of ineffective methods in both areas. In addition, participants increased student involvement with known poor spellers. Furthermore, participants either maintained or increased their effective strategies during follow-up. The authors cited the realism of the simulation and the clear, immediate feedback provided to the participants as the two major contributing factors to the effects of the simulation (Strang et al., 1989). Reinforcement in the form of correct student responses and compliance may have also contributed to the positive effects. A few years after this study, a meta-analysis of computer simulation studies was conducted.

In 1991, Thomas and Hooper classified and analyzed computer simulation studies based on their instructional function: experiencing, informing, reinforcing, and integrating. In experiencing simulations, the cognitive or affective stage was set for future learning by preceding formal presentation of the concept. Three of the five studies involving experiencing simulations demonstrated greater application and transfer of the materials, but appeared to have no effect on knowledge. One of the two studies that did not show any effects was non-interactive (Thomas & Hooper, 1991). Informing simulations provided information to the student in an initial exposure. Thomas and Hooper (1991) reviewed eleven studies in this category and only two reported positive results of the simulation, one of which suggested that simulation was better than no training at all. The authors concluded that the use of simulations to transmit information was inappropriate. In reinforcing simulations, students strengthened their learning objectives through application practice once teachers disseminated the material. The researchers reviewed seven studies in this category and the results were positive when non-disruptive feedback (e.g., feedback provided after the simulation) and teacher guidance were supplemental to the simulation (Thomas & Hooper, 1991). Integrating simulations required the user to integrate previously learned knowledge and apply it collectively. Researchers reviewed seven studies in this area and reported positive results in the areas of analysis and procedural questions, knowledge and skill transfer, achievement, professional decision-making, and problem diagnosis (Thomas & Hooper, 1991). Thomas and Hooper's (1991) conclusions suggest that effective simulations in teacher preparation occur when providing information first, and then requiring students to apply collectively the knowledge in real life situations, followed by feedback and/or participant guidance.

In 1999, Lee conducted a meta-analysis that included 19 studies on computer-based instructional simulation. Lee (1999) stated one of the reasons for conflicting results in previous research was the different instructional modes of simulation used: presentation of new knowledge, method of practicing what participants had already learned, or a hybrid of both methods, combining practice with guidance (Lee, 1999). Therefore, Lee (1999) classified hybrid simulation as having expository instructional features, and pure simulation as those that do not. Although Lee (1999) cited limited research using hybrid methods, she made the following conclusions regarding computer-based instructional simulations: (a) hybrid simulation was more effective than pure simulation for the presentation mode; (b) when hybrid simulation was used, presentation and practice modes were equally effective; (c) providing specific guidance appeared to increase student performance; (d) a negative attitude was shown towards simulation when students learned in the presentation mode within pure simulation; (e) students demonstrated little preference towards simulations in the practice mode; (f) simulation learning appeared to be a good fit for science subject matter (Lee, 1999). It seemed the last conclusion stemmed from the amount of research studies that involved science as the subject matter. Using only one identical study, Lee (1999) and Thomas and Hooper (1991) both concluded that simulations combined with guidance were more effective and that overall, participants only slightly preferred the use of instructional simulation to traditional classroom-based instruction.

The contradictions within the literature on simulations, even when focused solely on computer-based simulations, stem from the definitions used, the variety of supporting instructional environments, and the diversity of goals targeted (Thomas & Hooper, 1991). However, some similarities arose between the studies that reported positive results. First, the provision of immediate feedback, both during the session (intrinsic feedback; e.g., correct student responses and compliance) and after the session (extrinsic feedback) appeared to enhance participant performance in subsequent sessions. Second, the extent to which participants enjoyed the experience appeared to enhance the benefits of the computer simulation. Third, the realism of the experience appeared to have a positive effect on participant performance and retention of knowledge and skills. Given the conflicting results reported, it appeared that three key factors contributed to positive results when using computer simulation: immediate feedback, an enjoyable experience, and a realistic encournter. Thus, computer simulations may have the potential in the field of teacher preparation to move beyond traditional methodologies.

**Potential**

Computer simulations have the potential to be a powerful teaching resource as they offer rich learning experiences by actively engaging the learner through manipulation, exploration, and reflection (Flake, 1973; Lloyd & Idol-Maestas, 1983; Thomas & Milligan, 2004) through an experience that is much like the real world (Cruickshank & Telfer, 1980; Lee, 1999). They allow the user to experiment with principles previously learned (Flake, 1973) in college classroom lectures and textbooks by serving as a place for testing hypothesis and answering questions (Cruickshank & Telfer, 1980; Lee, 1999). Computer simulations offer unique opportunities by providing a learning environment that allows the user some control, permitting the attainment of learning goals beyond traditional learning and other computer-based instructional methods (Thomas & Hooper, 1991). Simulation affords users the opportunity to participate in the problem-solving process as opposed to simply observing someone else's strategy (Cruickshank & Telfer, 1980). In addition, computer-simulated environments allow the user to become acquainted with specific aspects of their work that they may not experience until later in their career (Cruickshank, 1969).

Computer simulations provide teachers with a personalized learning environment where the experience of self-directed professional development is facilitated and guided by expert coaches in a safe environment (Dieker et al., 2014) encompassing both intrinsic and extrinsic feedback. Allowing the manipulation of a system in which the user can observe the effects in a responsive environment (e.g., correct student responses and compliance) provides the user with intrinsic feedback (Cruickshank & Telfer, 1980; Thomas & Milligan, 2004) which is then enhanced by extrinsic feedback through coaching provided by an expert in the field. Computer-simulated environments allow for coaching immediately after the teacher's targeted session more easily than an actual classroom, because the avatar students do not need continuous monitoring once the session concludes. Therefore, computer-simulated environments offer a unique venue for feedback as they provide intrinsic feedback similarly to real classrooms, as student avatars respond to the teacher's behaviors in real time, with the added benefit of immediate extrinsic feedback, which coaches can provide just after the session, unlike teaching in real classrooms.

Computer-simulated environments also provide teachers with a personalized, individualized platform by allowing teachers to move at their own pace to ensure skill mastery, thus embracing student centric learning (Dieker et al., 2014). Learning to reflect during teaching and making the appropriate instructional adjustments in the moment may also be a skill that computer-simulated environments can help develop (Dieker et al., 2014). Reflection is important in teacher preparation and training because it allows teachers to experience a meaningful inquiry in which they can evaluate their practices, explore their thoughts and attitudes, and investigate new ways to improve their teaching (Calandra, Brantley-Dias, Lee, & Fox, 2009).

Computer-simulated environments provide teachers with a second attempt at teaching by providing the opportunity to practice newly learned teaching behaviors immediately after the reflection process has occurred (Dieker et al., 2014). After the initial attempt, the teacher can then change their approach based on their experience, the consequences of their actions, and the feedback they receive (Flake, 1973). Immediate feedback including knowledge of the results facilitates rapid learning (Flake, 1973). In addition, computer simulations are psychologically engaging as the user must make decisions in the moment and deal with both the intended and unintended consequences their decisions produce (Cruickshank & Telfer, 1980).

Computer-simulated environments make multiple attempts at teaching a concept, managing a classroom, and perfecting a teaching strategy possible. Whereas in a real classroom, unsuccessful teaching attempts may damage student rapport and waste valuable student learning time (Dieker et al., 2014) that could be spent using evidence-based practices. Effective simulations offer the opportunity for an accelerated skill acquisition, affording more time for the practice of advanced skills necessary for unusual and difficult situations (Strang et al., 1987). With a carefully controlled, programmed experience, teachers can experience the most critical situations in an environment that is free of threat and failure before actually having to face similar problems in their own classrooms (Cruickshank, 1969; Lloyd & Idol-Maestas, 1983). Further, computer-simulated environments facilitate the transfer of knowledge and skill from one setting to another and from acquisition to application (Cruickshank & Telfer, 1980; Dieker et al., 2014; Strang, 1990; Strang & Clark, 2003). Computer-simulated environments can be refined and enhanced to allow for the maximum impact on student learning and teacher performance (Dieker et al., 2014).

A 2006 survey of higher education faculty across disciplines revealed many positive attitudes towards the use of simulation in higher education (Lean, Moizer, Towler, & Abbey, 2006). Although only 11% of the respondents had ever used training simulations, an additional 66.5% stated they would consider using them in their own classrooms. The majority of all respondents stated they did not feel using new methods was risky, that students would react well to simulation, and disagreed with the statement that teaching innovation was a relatively low priority at their school (Lean et al., 2006).

Therefore, the results of this survey demonstrate the willingness of higher education faculty to incorporate simulations in their teaching.

**Implications**

Some disadvantages to using computer simulations in teacher preparation do exist. First, some faculty members remain unfamiliar with computer simulations and are therefore hesitant to use them (Cruickshank & Telfer, 1980). In addition, using computer simulations can require a larger amount of preparation time relative to the time requirement necessary for traditional class preparation methods (Cruickshank & Telfer, 1980), particularly for those individuals who have never used the technology. In 1980, Cruickshank and Telfer cited two disadvantages relative to the availability of computer simulations; they were simply less available and more expensive than traditional teaching materials. A 2006 survey by Lean and colleagues suggested that the perceived barriers of the use of simulation in higher education were limited time for teaching development, limited availability of resources to allow new methods of teaching, limited availability of technical or administrative support, and lack of awareness of available methods and products (Lean et al., 2006). While computer simulations are more readily available today, traditional teaching materials continue to be more accessible and less costly. According to Institutes of Higher Education, it is the student's financial responsibility to obtain the necessary materials (e.g., textbooks, CD's, software access) for each course, whereas the same Institutes of Higher Education would incur the cost of computer simulations themselves, resulting in a financial burden. One possible solution is that students' could be charged a lab fee for the use of the computer simulation, although it still would be the Institute of Higher Education that incurs the initial cost and it may take several semesters to cover the cost in full.

Moizer and colleagues (2009) revealed some additional concerns of higher education faculty with the use of simulations through discussions with interviewees. The authors found that higher education faculty were concerned with how well suited simulations and games were for their students, specifically if those students were accustomed to more passive, didactic forms of education (Moizer, Lean, Towler, & Abbey, 2009). In addition, interviewees discussed the risk involved with using simulations, specifically the possibility of negative unintended consequences such as diminishing the faculty's credibility and disrupting an otherwise smoothly running course (Moizer et al., 2009). Technical difficulties also pose a risk in the use of computer simulations (e.g., technology stops working, a delay between motion and sound, sound is absent, etc.; Moizer et al., 2009). Such risks pose real threats to the use of computer simulation in teacher preparation.

Moizer et al. (2009) offered ideas for the implementation of several support mechanisms to overcome these barriers. First, providing time for faculty to plan and organize lessons using simulation and for collaboration between faculty members in their use of simulations could mitigate the risk. Second, the provision of formal training and development activities could increase faculty's knowledge and skill level, expertise, and confidence with using simulations in their teaching (Moizer et al., 2009). Educators could demonstrate differentiation within simulations through training and development activities, addressing the concern regarding the appropriateness of simulations for all students.

Although previous research has demonstrated the educational benefit of computer-simulated environments (Girod & Girod, 2008), past research also suggested that their educational benefits were not automatic (Thomas & Milligan, 2004). In order for computer-simulated environments to be successful as measured by improved skill development and performance, educators must place the emphasis on the educational components, not the simulation itself (Cruickshank & Telfer, 1980; Guralnick & Levy, 2009). Therefore, educators must carefully create situations in order to provide specific learning objectives paired with guidance, feedback, and support (Guralnick & Levy, 2009; Thomas & Milligan, 2004). Effective support within computer-simulated environments can be provided by experts in the field (i.e. teachers and coaches; Thomas & Milligan, 2004) through a cyclical process. The cyclical process is one of three critical components for effective teacher preparation in computer-simulated environments (Dede, 2009).

Three critical components in other professional fields have been shown to ground the impact of computer-simulated environments in behavior (Dieker et al., 2014). The first critical component is the cyclical process. In teacher education, the cyclical process begins with the statement of an objective of the observation, followed by the observation itself, and ends with a debriefing about behaviors observed (Dieker et al., 2014). In the computer simulation world this process is call the Action Review Cycle (ARC; Darling, Parry, & Moore, 2005). Using the ARC in computer-simulated environments allows teachers to self-reflect, ask questions, and receive coaching (Dieker et al., 2014). Three stages occur in the ARC, allowing teachers to reflect before and after the observation, providing them with a personalized learning platform. In the first stage, teachers plan for what they want to learn from the experience (Before Action Review). Next, the teacher experiences the computer simulation (Action) and finally the teacher assesses the gap between what was expected and the actual results (After Action Review; Dieker et al., 2014). This ARC has shown to be the basis for effective support within some computer-simulated environments and is evident in early computer simulation research.

Another critical component of computer-simulated environments is the phenomenon of 'real presence' (Dede, 2009). Computer-simulated environments are effective when they provide teachers with a personalized experience they believe is real (Dieker et al., 2014). Dieker and colleagues (2014) liken this experience to teachers implementing behavior management strategies in real classrooms as compared to reading about behavior management in a textbook. The teacher must feel personally responsible for improving their own practice and engage in the process of self-reflection (Dieker et al., 2014). Again, realism was a contributing factor to positive results demonstrated in early computer simulation research.

Similar to realism, the third critical component is suspension of disbelief. The belief of being physically and cognitively present occurs when there is a high level of engagement between the individual and the technology (Dede, 2009). Dieker and colleagues (2014) illustrated this concept by comparing it to interacting with a theme-park character. Although we know that the character is just a person in a costume, the theme park environment suspends our belief of the real world and we believe that the character is real (Dieker et al., 2014). Dieker and colleagues (2014) hypothesized that when teachers engage in virtual reality environment experiences that contain these three critical components, the result will be improved content knowledge for both teachers and students, improved teacher pedagogical knowledge, and enhanced teacher ability to address individual student needs.

Dieker and colleagues (2014) posit that as virtual environment technology evolves every year, educators will expect greater teacher learning gains and that by pairing advancements in technology with the standardized reflection process, the field of teacher preparation will reap a strong and lasting impact. It is possible that the early computer simulation work did not take off in teacher preparation due to the time intensive planning and preparation process as well as high cost. One virtual reality environment, TLE TeachLivE™, offers a solution to these drawbacks, as teacher educators do not need to recreate the virtual reality, but can simply access the technology via the internet from satellite sites.

**TLE TeachLivE™**

One current computer-based simulation used in teacher preparation is the virtual reality environment, TLE TeachLivE™. TLE TeachLivE™ (Teaching and Learning in an Interactive Virtual Environment) is a computer-simulated learning lab designed to provide educators a place to practice teaching with virtual characters (avatars) manipulated by human performers (interactors) in a realistic virtual setting in which interactions occur in real time and can be scripted or spontaneous (Vince-Garland, 2012). The University of Central Florida (UCF) developed this computer-simulated environment, which 42 campuses across the United States are currently using, allowing teachers to learn new skills and perfect their practice without placing real students at risk during their learning process (TLE TeachLivE™, 2015).

The program, information technology (IT) support, and interactors, are located at UCF. The interactors are human performers who play the part of the student avatars, controlling both their voice and movements, as the participant is interacting with the student avatars from their satellite site. The satellite sites have the physical set up of the lab at their location. The physical set up includes a wide-screen television, a computer, the satellite technology (installed by IT from UCF), an Xbox Kinect, and a microphone. Participants stand in front of the wide screen television and the avatars on the screen can respond in real time, both physically and verbally, through the interactor, to the participant's actions and verbalizations. The Xbox Kinect captures participant's physical movements, allowing the participant to 'walk' around the classroom to gain various perspectives and physically interact with individual students. The Xbox Kinect also allows the interactor, or student avatar, to respond to the participant's motions (e.g., giving a high five or pointing to an item the participant is holding). The interactors at UCF receive a lesson plan and instructions from the satellite site prior to the lab time to ensure all parties are working towards the same goal. Therefore, many teacher preparation programs are using TLE TeachLivE™ across the United States, without having to recreate or purchase an entire virtual reality system.

TLE TeachLivE™ has the capabilities of providing the required components of effective computer simulations as specified by past research. First, expert coaches communicate specific learning objectives to both the participant and the interactor, so the coach prepares the participant for the carefully controlled practice session and the student avatars can react in a manner that provides appropriate intrinsic feedback to the participant in order to assist them in reaching the specified objective. In addition, the expert coach provides extrinsic feedback in the form of guidance, feedback, and support. Not only does TLE TeachLivE™ possess the capabilities outlined in education research, it reflects the core components of virtual environments in other fields.

Similar to computer simulators in other professional fields, TLE TeachLivE™ includes the core components that ground the impact of virtual environments on teacher behaviors: the cyclical process, real presence, and suspension of disbelief. The cyclical process, or Action Review Cycle (ARC), begins with the statement of an objective of the observation, followed by the observation itself, and ends with a debriefing about behaviors observed (Dieker et al., 2014). Using the ARC in TLE TeachLivE™ allows teachers to self-reflect, ask questions, and receive coaching. TLE TeachLivE™ also offers the components of real presence and suspension of disbelief as participants have indicated in past research studies they feel as though the student avatars were real (e.g., Elford, Carter, & Aronin, 2013). Therefore, TLE TeachLivE™ has the potential to decrease student's exposure to under-prepared, ineffective teaching, thereby improving teacher practice, which can lead to increased student achievement (Dieker et al., 2008).

**TLE TeachLivE™ Research**

Research using TLE TeachLivE™ is currently in its beginning stages. Seven research projects have been completed at UCF (four of which were unpublished doctoral studies) and one large scale three-year research study is currently being conducted (Dieker et al., 2014). In one of the research projects, Andreasen and Haciomeroglu (2009) studied an earlier version of the computer-simulated environment. Two of the studies, one a pilot for a dissertation (Vince-Garland et al., 2012) and the unpublished dissertation itself (Vince-Garland, 2012) used TLE TeachLivE™ to train pre-service teachers to use Discrete Trial Teaching (DTT). Researchers have conducted studies using TLE TeachLivE™ at other universities, which included a pilot study conducted by Myers, Reier, and Lignugaris/Kraft (2010) that prepared teachers to implement DTT and a study by Elford, Carter, and Aronin (2013) that used bug-in-ear coaching.

Andreasen and Haciomeroglu (2009) examined the potential of TeachME, an earlier version of TLE TeachLivE™, by training 15 pre-service secondary mathematics teachers within the computer-simulated environment. These pre-service teachers developed and taught math lessons during a semester-long methods course in groups of three. First, each group planned and wrote a detailed algebra lesson plan. Within the computer-simulated environment, these pre-service teachers encountered correct, incorrect, and incomplete student work samples in which they were to discuss with the class of student avatars. Each pre-service teacher wrote a reflection after the teaching session, then watched a video of the session, and subsequently revised their lesson plans to prepare for the next teaching session. The researchers adjusted the level of student avatar behavioral responses in order to challenge the pre-service teachers during each teaching session.

Qualitative data were collected via videos of the teaching sessions, classroom discussions, interviews, classroom observations, student's lesson plans, and reflections. Andreasen and Haciomeroglu (2009) anecdotally reported two of the teaching episodes in their report. Although the authors stated this was a "mixed study," the quantitative data collected was not reported in the brief paper (Andreasen & Haciomeroglu, 2009, p. 3). The authors concluded that TeachME had the potential to deepen pre-service teacher's content knowledge through discussions of student work samples as well as to help develop their behavior management strategies (Andreasen & Haciomeroglu, 2009). As this was a report presented at an annual meeting and not a published research study, the authors did not provide all results. The authors have not published this research study in a peer-reviewed journal to date. Although Andreasen and Haciomeroglu (2009) did not report quantitative data, the qualitative data reported provided insight into the teachers' thought processes and experiences during the study. This insight is a key piece in determining *how* the computer simulation experience changed pre-service teacher behaviors.

Elford, Carter, and Aronin (2013) studied bug-in-ear coaching with four secondary teachers who practiced providing student feedback for the purpose of classroom management within TLE TeachLivE™. Coaches provided training, modeling, cuing, and guided reflection to the teachers. Each teacher taught one lesson over four sessions. Although the teachers wore the Bluetooth device during all four sessions, they only received coaching in two of those sessions and did not know in which two sessions they would receive coaching until the lesson began. The researchers did this so the teachers did not receive a prompt by the presence of the bug-in-ear device alone. Data were collected on the percentage of disruptive behaviors addressed using positive feedback (Elford et al., 2013).

The results indicated that all four teachers increased the amount of positive student feedback to address disruptive behaviors through remote coaching (Elford et al., 2013). Overall, teachers increased the amount of positive student feedback they provided by 20% to 30% across sessions. In fact, during the final session, two of the four teachers provided positive feedback 100% of the time, even though the researchers were not coaching them. During post-session interviews, all four teachers expressed their surprise regarding how quickly they adjusted to the computer-generated images and began to interact with the avatars as though they were real students. Elford et al. (2013) concluded that bug-in-ear technology combined with simulated technology "make a powerful professional learning experience for secondary teachers" (p. 43).

Several limitations exist within Elford and colleague's (2013) study. First, the lack of data including no baseline, generalization, or maintenance data is important to note. In addition, as teachers wore the Bluetooth device across all sessions, it is unknown whether this served as a prompt in and of itself to provide student feedback. The authors did not discuss the type of design, as the focus of the article was not on the research study itself.

Myers, Reier, and Lignugaris/Kraft (2010) conducted a pilot study to teach educators of students with significant disabilities to implement Discrete Trial Teaching (DTT) and examined the extent to which teachers' practice of DTT in the TeachME lab transferred to the teacher's own classrooms. Two novice teachers, one male and one female, participated in the study. First, researchers observed the participants teaching a DTT lesson in their own classroom in baseline, prior to any instruction or coaching. During the intervention phase, participants first watched a modeled forced choice reinforcement assessment, and then conducted a three to five minute forced choice reinforcement assessment with one avatar in order to get to know him. Next, the participants watched a DTT lesson in which the coach modeled with the avatar the correct DTT steps. Finally, the participants implemented the same DTT lesson with the avatar while being coached. During this final stage, visual prompts were located on the wall and the lesson was paused in order for the coaches to provide immediate feedback and error correction (Myers et al., 2010).

Results of the study indicated that both participants improved significantly on the percentage of DTT steps performed correctly (Myers et al., 2010). Teacher one improved from 0% at baseline to 74% during the intervention phase. Teacher two improved from 34% at baseline to 64% during the intervention phase. Both teachers scored 100% correct in the generalization probe conducted in the teachers' own classroom. Therefore, not only did the teachers improve their DTT implementation in the TeachMe lab, they were able to generalize the newly learned strategy to their own classrooms (Myers et al., 2010).

Several limitations existed within the Myers et al. (2010) study, although the researchers did not report them in the presentation. The researchers reported few data points, no baseline in the TeachME lab, and involved only two participants (Myers et al., 2010). Further, the researchers did not collect maintenance probes or student data. In addition, this was an AB design, so there was neither a reversal phase nor the incorporation of a multiple baseline where the teachers began the intervention at different times. Although the authors cited implications of the study including decreased time for supervision/coaching relative to on-site supervision/coaching (e.g., no travel time), and no harm to real students (e.g., no consequences if teachers made mistakes), there was no comparison between in-class training and training within the TeachMe lab. The authors also discussed the pros of being able to pause the classroom/avatars and to coach the teachers unobtrusively, although the researchers did not compare this method to one in which coaches provided feedback immediately after the session. Lessons learned from the pilot study cited by the authors included the necessity of an introduction to the technology for the participants, providing clear, targeted expectations, having a defined scope and sequence that describes the specific skills to be learned in the lab, and clear, succinct coaching skills (e.g., when to provide error correction or feedback; Myers, et al., 2010).

In a pilot study, Vince-Garland, Vasquez, and Pearl (2012) evaluated the efficacy of individualized coaching in TLE TeachLivE™ on teacher's fidelity of implementation of DTT in a multiple baseline across participants design with four graduate students employed in K to 12 schools. First, in the baseline phase, participants conducted 10 trials of DTT with an avatar with typical ASD characteristics in the virtual reality environment. Then, the coaching piece of the intervention was implemented, which consisted of a review of the participant's previous performance, modeling of correct procedures by the researcher, and then participant practice with the researcher providing immediate corrective feedback after each step completed incorrectly (outside of the virtual environment). Finally, the first author modeled the correct procedures with the avatar within TLE TeachLivE™ and then the participant conducted another 10 trials with the avatar (Vince-Garland et al., 2012).

Visual analysis demonstrated a functional relationship between coaching in TLE TeachLivE™ and fidelity of implementation of DTT (Vince-Garland et al., 2012). Three of the four participants improved from a mean of 37% fidelity in baseline to a mean of 87% after only six coaching sessions. Due to time constraints, the fourth participant only received one intervention session (Vince-Garland et al., 2012). The results support that teachers were able to reach fidelity of implementation of DTT within the virtual reality environment, TLE TeachLivE™, in a short period.

No specific threats to internal validity were present. However, a threat to external validity existed, specifically generality across settings and time (Kazdin, 2011), as neither generalization nor maintenance probes were conducted. Therefore, it is unknown whether teachers were able to generalize their newly acquired skills to their own classrooms with their own students. If the teachers were only able to execute DTT in the controlled virtual reality environment then it raises a question about the importance of the intervention. Further, without maintenance probes, it is unknown whether the teachers were able to maintain implementation fidelity in any environment (i.e., their own classroom or TLE TeachLivE™). In addition, the researchers did not measure the impact the intervention had on student's skill acquisition. Finally, the researchers used the same academic skill throughout the intervention, which may decrease skill transferability. However, the article provided sufficient detail to allow for replication of the intervention.

Vince-Garland (2012) extended the previous pilot study with five teachers enrolled in a graduate program who had no formal training in DTT, again measuring the efficacy of individualized coaching in TLE TeachLivE™ on teacher's fidelity of implementation of DTT in a multiple baseline across participants design. The researcher added two generalization probes in order to measure participant's ability to transfer skills to their own classrooms. Participants improved from a mean of 12% at baseline to a mean of 96% in intervention. Generalization probes ranged from 75% to 96%, with a mean of 90%. All five participants strongly agreed TLE TeachLivE™ positively enhanced the training and all agreed the coaching component had a greater impact on learning compared to traditional modalities (Vince-Garland, 2012).

Several limitations of the study are worth noting. First, participants reported feeling uncomfortable interacting in the lab during baseline (Vince-Garland, 2012). Second, the researcher only conducted maintenance probes two weeks after the intervention. Third, participants were not required to reach fidelity while the avatar engaged in moderate ASD-like behavioral characteristics. Finally, similar to the pilot study, only one academic skill was used for the duration of the intervention, which may decrease skill transferability.

Taken together, previous research suggests that TLE TeachLivE™ with coaching has the potential to successfully train pre-service and in-service teachers in a variety of skills, including math content knowledge, behavior management strategies, student feedback, and DTT.

# CHAPTER THREE

# METHODOLOGY AND PROCEDURES

The purpose of the current study was to measure the effectiveness of two training modalities, a didactic presentation and individualized coaching in a virtual reality environment (TLE TeachLivE™) on special education teachers' implementation of DTT. This chapter provides information regarding the methodology and procedures used in the current study. First, the research questions are stated. Next, the participants, setting, and materials are reviewed. Then, the measures and data collection procedures are discussed including the dependent and independent variables, assessment measure, data collectors, and general procedures which include a description of baseline, intervention, classroom probes, generalization and maintenance, interobserver agreement, procedural integrity, and social validity. The chapter concludes with an explanation of the experimental design and data analysis plan.

## Research Questions

The following research questions were addressed:

1. How does viewing a prerecorded didactic training effect special educators' implementation of Discrete Trial Teaching (DTT) in their own classroom with students diagnosed with autism spectrum disorders (ASD)?
2. How does coaching in a virtual reality environment effect special educators' implementation of DTT in their own classroom with students diagnosed with ASD?
3. Can the results of these trainings (implementation of DTT with fidelity) be maintained by special educators' in their own classroom with students diagnosed with ASD over time?

**Participants, Setting, and Materials**

This study was conducted at Kennedy Krieger Institute's (KKI) LEAP (Lifeskills and Education for Students with Autism and other Pervasive Behavioral Challenges) and Fairmount schools, both nonpublic separate special education day schools. LEAP serves students who are severely impacted by ASD and who struggle with significant behavior challenges. LEAP is an intensive, year round program with a focus on highly structured, safe environments, which allow students to participate in and receive benefit from their educational programming. LEAP has approximately 60 students, ages 5 to 21 years, and 11 teachers. Fairmount is an 11-month program that provides students with a highly supportive environment that addresses the unique, educational and therapeutic needs of each student. Fairmount serves approximately 165 students, from kindergarten through $8^{th}$ grade and has 21 teachers. A total of five teachers across both schools were selected to participate in this study. As three participants are the minimum (Kazdin, 2011), five participants were enlisted to allow for dropout and to increase internal validity by providing more opportunities for prediction, verification, and replication.

**Participant selection procedures.** Participant selection consisted of the following steps. First, the following inclusion criteria were used: (1) special education teachers had to be currently implementing DTT in their classroom, and (2) special education teachers had to have at least one student diagnosed with ASD in their current classroom. This narrowed the number of potential participants from 31 down to 15 (10 teachers from LEAP and five teachers from Fairmount). Second, these 15 teachers were observed completing 10 trials of DTT with a student in their classroom. During this observation, the researcher scored the special education teacher using the DTT Implementation Steps Checklist

(DTTISC). The five teachers with the lowest implementation scores were contacted to participate in the study. As this study aligns with KKI schools' current professional development initiatives (i.e., standard educational practice) participants were required to inform their supervisor as well as the primary investigator if they did not wish to participate.

**Participants.** Based on the results of the observations, five special educators within KKI LEAP and Fairmount schools were selected and agreed to participate in the study. See Table 1 for a summary of participant characteristics.

[Insert Table 1 here]

***Megan.*** The first participant, Megan, was a fourth year teacher at KKI's Fairmount campus. Megan was in the 30 to 34 year old age range. Prior to becoming a teacher, Megan worked as a paraeducator for one year and a teaching assistant for two years. Megan earned a Master's degree in the area of special education/ severe and profound disabilities. She reported five years of experience implementing DTT. Megan was certified by the Maryland State Department in the area of special education/ severely and profoundly disabled.

***Layla.*** The second participant, Layla, was a third year teacher at KKI's Fairmount campus. Layla was in the 25 to 29 year old age range. Prior to becoming a teacher, Layla worked as a paraeducator for two years and a teaching assistant for two years. Layla earned a Master's degree in the area of special education. She reported two years of experience implementing DTT. Layla was certified by the Maryland State Department in the area of special education/ elementary and middle.

***Pamela.*** The third participant, Pamela, was a first year teacher in KKI's LEAP program. Pamela was in the 25 to 29 year old age range. Prior to becoming a teacher, Pamela worked as a paraeducator for two years and a teaching assistant for two years. Pamela earned a Master's degree in the area of special education. She reported five years of experience implementing DTT. Pamela was certified by the Maryland State Department in the area of special education/ elementary and middle.

***Juliette.*** The fourth participant, Juliette, was a fifth year teacher in KKI's LEAP program. Juliette was in the 25 to 29 year old age range. Prior to becoming a teacher, Juliette worked as a paraeducator for one year and a teaching assistant for one half a year. Juliette earned a Master's degree in the area of special education/ severe and profound disabilities and applied behavior analysis. She reported two years of experience implementing DTT. Juliette was certified by the Maryland State Department in the areas of elementary education and special education/ elementary and middle and severely and profoundly disabled.

***Kerry.*** The fifth participant, Kerry, was a first year teacher in KKI's LEAP program. Kerry was in the 30 to 34 year old age range. Prior to becoming a teacher, Kerry worked as a paraeducator for one year and a teaching assistant for one year. Kerry earned a Bachelor's degree in the area of sports management and was currently taking classes in a Master's degree program in the area of special education/ severe disabilities. She reported two years of experience implementing DTT. Kerry was provisionally certified by the Maryland State Department in the area of special education/severely and profoundly disabled.

**Setting.** All phases of the study took place onsite at the two school campuses of Kennedy Krieger Institute. Data were collected in the participant's classroom in the participant's respective school, LEAP or Fairmount. Although both schools are in Baltimore City, the campuses were approximately seven miles apart. For the didactic training, participants viewed the prerecorded PowerPoint on their own computer on their own time. Coaching in the virtual reality environment took place in the TLE TeachLivE™ lab, located at KKI's Greenspring campus (i.e., where LEAP and the High School programs are both located).

***TLE TeachLivE™ lab.*** The TLE TeachLivE™ lab was located in a 12 foot by 15 foot room. The main room had two smaller 6 foot by 8 foot rooms off of one side at either end of the wall, both with access doors. The main room contained a 54-inch wide-screen television placed on a stand that had the capability of moving up and down. Housed below the television were an Xbox Kinect and two speakers. One small rectangular table and one small circular table were also in the room, accompanied by four chairs. In the first smaller, adjoining room there was a desk with a computer, hardware, and software for the TLE TeachLivE™ program. In the second smaller, adjoining room there was a small rectangular table and two chairs. There were no decorations on the walls in any of the three rooms. The large room had one window on the wall across from the access door. The coaching intervention took place in the main room.

***Megan's classroom.*** Megan's classroom had one small rectangular table set up where one-to-one instruction took place. The area was closed off on three sides with one wall, a bookcase, and a room divider. One-to-one instruction also took place in a small adjacent observation room containing a small rectangular table and two chairs. Megan's classroom contained seven students and six staff (Megan, one teaching assistant, and four program aides). Her students were in grades seventh and eighth. The other students and staff were present during all classroom observations.

***Layla's classroom.*** Layla's classroom had one u-shaped table set up in the back where one-to-one instruction took place. Layla's classroom contained eight students and nine staff (Layla, a teaching assistant, and seven program aides). Her students were in grades second through fifth. The other students and staff were present during all classroom observations.

***Pamela's classroom.*** Pamela's classroom had three small rectangular tables set up where one-to-one instruction took place. Pamela's classroom contained six students and eight staff (Pamela, a teaching assistant, and six program aides). Her students were in grades seventh and eighth. The other students and staff were present during all classroom observations.

***Juliette's classroom.*** Juliette's classroom had three small rectangular tables set up where one-to-one instruction took place. Juliette's classroom contained six students and seven staff (Juliette, a teaching assistant, and five program aides). Her students were in grades sixth through ninth. The other students and staff were present during all classroom observations.

***Kerry's classroom.*** Kerry's classroom had three small rectangular tables set up where one-to-one instruction took place. Kerry's classroom contained seven students and eight staff (Kerry, a teaching assistant, and six program aides). Her students were in grades ninth through eleventh. The other students and staff were present during all classroom observations.

**Materials.** Materials used for DTT implementation in the TLE TeachLivE™ lab encompassed five teaching tasks. The first teaching task was letter identification. Five blue, three and a half inch tall capital letters were printed on four inch by six inch index cards (i.e., B, C, S, T, and N). The second teaching task was action identification. Five photographs of children performing an action on four inch by six inch index cards were used for this task (i.e., running, pushing, pulling, jumping, and sleeping). The third teaching task was set identification. Sets of one to five objects (a dog, yellow smiling faces, cars, basketballs, and strawberries, respectively) appeared on four inch by six inch index cards. The fourth teaching task was functional sign identification (i.e., stop, bathroom, walk, don't walk, hospital). Laminated signs ranged in size from twelve inches by twelve inches to eight inches by four inches. The fifth teaching task was function identification and included a glove, sock, hand towel, pencil, and toothbrush. The teaching tasks were chosen at random prior to the intervention for each session using an online random number generator.

**Measures and Data Collection Procedures**

A description of the measures and data collection procedures are presented in the following four sections. The first section defines the dependent and independent variables. The second section describes the assessment measures used in the study. The third section describes the data collectors. The fourth section describes general procedures for baseline, both phases of intervention, generalization, interobserver agreement, procedural integrity, and social validity.

**Dependent Variable.** The dependent variable was the percentage of correctly implemented steps of DTT as measured by the Discrete Trial Teaching Implementation

Steps Checklist (DTTISC; see Appendix A) during each classroom observation across the four phases of the study. The DTTISC was also used to evaluate the special educators' performance in the TLE TeachLivE™ lab, but these data were only used for supplemental information. The DTTISC was adapted from Fazzio & Martin's (2011) DTT Evaluation Form and Vince Garland's (2012) DTT Evaluation Rubric.

The DTTISC included five sections: initial set up (five steps), managing the antecedents (two steps), managing the consequences (two to four steps), managing the inter-trial interval (two steps), and the conclusion (two steps). The skill area of initial set up consisted of five steps: get task materials and data sheet ready, get reinforcers ready, invite student to the table, identify reinforcer, and review activity schedule. The area of managing the antecedents consisted of two steps: say student's name and wait for them to look in your direction and present teaching materials with correct instruction. The area of managing the consequences encompassed two sections, one section for correct responses and one for incorrect responses. The section for correct responses consisted of two steps: provide specific verbal praise and provide selected reinforcer. The section for incorrect responses consisted of four steps: immediately remove materials, show neutral expression for two to three seconds, represent instruction and materials with proximity prompt, and verbally affirm correct response. Managing inter-trial interval consisted of two steps: record response and provide three to five second break at seat. The two steps in the conclusion section were: to indicate finished on activity schedule and state next activity.

Sections one and five (i.e., initial set up and conclusion) were only scored once per 10-trial set while sections two through four were scored in each of the 10 trials. The third section, managing the consequences, consisted of two subsections: correct response and incorrect or no response. For each trial, participants were only scored on one of the subsections, depending on the student's response. When observations resulted in a score of "not applicable" (e.g., steps eight and nine in managing the consequences for correct responses, if the student response was incorrect and steps 10 through 13 in managing the consequences for incorrect or no response if the student response was correct), the "not applicable" items were not included in the total score. In contrast, if step six in managing the antecedents was not applicable because the student was already looking in the teacher's direction, this step was scored as correct and included in the total score. Therefore, the total number of teacher steps for *each trial* was either six (for correct student responses) or eight (for incorrect student responses), resulting in a minimum total of 67 steps and a maximum total of 87 steps per 10-trial set. The total number of correct student responses was recorded on the DTTISC in order to determine the appropriate total number of teacher steps. All scores were converted to a percentage by dividing the number of correct steps by the number of total steps and multiplying by 100.

**Independent Variables.** Two independent variables were employed in this study. The first independent variable was the didactic training on DTT, which encompassed skills in five areas: (1) initial set-up, (2) management of antecedents, (3) management of consequences for a correct response, (4) management of consequences for an incorrect response, and (5) management of the inter-trial interval (see Appendix A). The didactic training consisted of a prerecorded PowerPoint presentation with audio and visuals to ensure uniformity across participants and was approximately one hour in length. Information in the presentation was adapted from Fazzio and Martin's (2011) self-instructional manual on implementing DTT with children with ASD. Participants viewed the presentation individually on their own computer.

The second independent variable was individualized coaching within the virtual reality environment, TLE TeachLivE™. The individualized coaching session was comprised of feedback, modeling, and practice within the TLE TeachLivE™ virtual reality lab.

**Data Collectors.** Primary data were collected by the researcher across all phases. A graduate assistant who was familiar with DTT provided interobserver agreement and procedural integrity ratings. The graduate assistant was trained to use the assessment measure, the DTTISC, and in the coaching procedures (see IOA section under General Procedures for details regarding training).

**General Procedures.** Procedures are described in the following subsections: baseline, intervention, maintenance, interobserver agreement, procedural integrity, and social validity.

***Baseline.*** Baseline data were collected in the teacher's own classroom with a student diagnosed with ASD. Each teacher completed 10 trials of DTT with the teacher-selected student per session. A minimum of five sessions were conducted in baseline for each participant. The participant who demonstrated the most stable baseline trend entered the first phase of the intervention. The first five sessions represented a relatively stable trend for the other four participants, so the continuous collection of baseline data ceased and one final baseline probe was collected just prior to the participant entering the first intervention phase. The final baseline data point helped to rule out any learning that may have taken place prior to the first intervention.

***Intervention phase 1: Didactic training.*** Each participant received a flash drive with a pre-recorded PowerPoint presentation describing DTT implementation and three days to view the one hour presentation. Participants were instructed to view the presentation only once and not to review or rewind any portions (since this option would not be available during a typical face-to-face professional development). Participants then viewed the presentation on their own time. Within one to three days of viewing the pre-recorded PowerPoint presentation, the participants implemented 10 trials of DTT with a teacher-selected student in their classroom who was diagnosed with ASD. The researcher scored the participants using the DTTISC, but did not provide feedback to the participants regarding their performance. Once the participant displayed a stable or decreasing data trend over a minimum of three sessions, they entered phase two of intervention.

***Intervention phase 2: Coaching/ TLE TeachLivE™ lab.*** The second intervention phase consisted of individualized coaching including feedback, modeling, and practice, within a virtual reality environment, TLE TeachLivE™. Each special educator met with the coach and engaged in a brief introduction activity prior to their first session in the lab in order to increase familiarity with the virtual classroom and the avatars. This activity consisted of introductions and a brief social interaction between the special educator and the avatars (e.g., asking the student avatars about their school day, their upcoming weekend, the weather, their afterschool activities, etc.). During each session, the special educator was seated at a small round table in the lab facing the television screen and was provided with a microphone that was placed around their neck. Special educators engaged in lab sessions two to three times per week.

The beginning of the first session differed slightly from all subsequent sessions (see Figure 1). During the first session, the researcher first reviewed the DTTISC from the participant's previous classroom observation, providing specific positive praise for correct components and corrective feedback for components implemented incorrectly. As such, the participant's last observation during the didactic training phase was reviewed during the first coaching session. This review took place prior to the participant implementing DTT with Austin the student avatar, to avoid the participant practicing the components incorrectly. The researcher then answered any questions the participant posed. Next, procedures specific to Austin and the TLE TeachLivE™ lab were reviewed with the participant. First, the participant was instructed to say "start classroom" when they were ready to work with Austin. Next, the participant was instructed to briefly engage with the student avatars in the class and then tell the students that she was going to work with Austin so they were to work on their independent work. The first coaching session took approximately 45 minutes per participant. In the second session and all subsequent sessions, the participant was asked if they remembered these beginning procedures. As only one to three days elapsed between lab sessions, participants rarely had questions.

After the beginning procedures during the first session, and at the start of each subsequent session, the procedures during this intervention phase were identical. After entering the TLE TeachLivE™ lab, having a seat at the table, and placing the microphone around their neck, the participant would say "start classroom." After briefly engaging with all students, the participant would tell the students that she was going to be working with Austin so they were to do work on their independent work. The participant would then invite Austin, the student avatar, to the table and provide him with a choice of reinforcers by asking him if he wanted to work for fist bumps or high fives (while modeling the action of each). Next, the participant reviewed the activity schedule by telling Austin that they would first work on (the randomly chosen activity for the session) and then he would have a break. Next, the participant would conduct 10 trials of DTT with Austin, concluding with the final steps, indicating that Austin was finished and that it was time for him to take a break. After conducting the first DTT session, the special educator paused the classroom, indicating their readiness to begin coaching.

During the coaching portion of the intervention the researcher sat next to the participant at the table. First, the researcher provided the participant with general positive feedback regarding the session as a whole. Next, the research shared the DTTISC that was scored during the previous 10 trials of DTT with the participant, showing the participant the form as she explained their performance on each component. Specific positive praise was provided for each component performed correctly and corrective feedback was provided for each component performed incorrectly both verbally and in written format (via the DTTISC; see Figure 1 for complete coaching sequence). Due to the complexity of the steps in the "manage the consequences" sections, procedures were also modeled by the researcher if the participant performed any of the steps incorrectly. For the second and all subsequent sessions, the participant's previous observation took place after at least one coaching session in the lab. Performance in both the lab and the participant's classroom were reviewed as the lab is a controlled setting and the ability of the participant to perform DTT with fidelity in their own classroom demonstrates their ability to generalize procedures from a controlled lab setting to the actual classroom setting with students with ASD. The researcher then provided the participant with general positive feedback and answered any questions the participant posed. Next, the participant conducted another 10 trials of DTT with Austin. The researcher again scored the participant using the DTTISC and followed the same procedures to review their performance.

[Insert Figure 1 here.]

During each DTT session of 10 trials, Austin, the student avatar, demonstrated five correct responses and five incorrect responses in random order, allowing participants to practice both error correction and positive reinforcement. In addition, at the beginning of at least five of the 10 trials, Austin was looking away from the participant so the participant had to gain his attention prior to giving the instruction.

***Classroom observations.*** All graphed data were collected via classroom observations for all phases of the study (i.e., baseline, didactic training, coaching in the TLE TeachLivE™ lab, and maintenance). Data were collected on consecutive days or up to three days apart during baseline and both intervention phases. Data were collected for each participant during one DTT session (10 trials) in the participant’s classroom with one of their students diagnosed with ASD for each phase. The researcher completed the DTTISC for each observation and a percentage correct was recorded and graphed. During the Coaching in TLE TeachLivE™ intervention phase, classroom data were collected during the school day and then the participant received coaching in the TLE TeachLivE™ lab at the conclusion of the school day. Therefore, one classroom observation took place the following day or up to three days after the coaching session in the TLE TeachLivE™ lab for every participant. Feedback was given to participants during the coaching session in the TLE TeachLivE™ lab, not in the classroom.

***Maintenance.*** Maintenance probes were scheduled at two, four, and six weeks after the coaching intervention for each participant in the teacher's own classroom with one of their students diagnosed with ASD. However, due to holiday and weather related school closings, maintenance probe data were collected from two to eight weeks after the conclusion of the coaching intervention.

***Interobserver agreement.*** All baseline, intervention phase one (didactic training), intervention phase two (coaching in the virtual reality lab), and maintenance sessions were video recorded and 30% of all sessions across participants, settings, and phases were randomly selected for interobserver agreement (IOA) using an online random number generator. The primary investigator trained a fourth year doctoral student to use the assessment measure (the DTTISC) to score each video recorded observation.

The primary investigator provided IOA training to the doctoral student. First, the primary investigator provided an explanation of the DTTISC to the doctoral student, including examples and non-examples of each step. Next, two videos were chosen that were not randomly selected for IOA to use for training purposes using an online random number generator. The doctoral student independently viewed the videos and scored the participant using the DTTISC. Third, the two DTTISC's were compared on a point-by-point basis to determine IOA. Fourth, the primary investigator and the doctoral student viewed each video together to discuss any disagreements. Once an agreement was reached between the primary investigator and the doctoral student on 95% of the steps, training was considered completed.

Next, remaining blind to the phase of the study, the doctoral student observed the randomly selected sessions independently and scored the teacher's fidelity of implementation using the DTTISC. The two assessment measures were examined on a point-by-point basis for agreement and IOA was calculated by dividing the number of agreements by the number of agreements plus the number of disagreements multiplied by 100 (Kazdin, 2011).

***Procedural integrity.*** Fifty percent of sessions from the coaching in the TLE TeachLivE™ lab across participants was selected randomly for evaluation of procedural integrity (similar to Bethune & Wood, 2013). Videos were examined by a fourth year doctoral student to ensure adherence to the intervention procedures. Procedural integrity was measured using a checklist for the researcher's behaviors during the intervention sessions (see Appendix B). The number of steps performed correctly by the researcher was divided by the number of possible steps and multiplied by 100 to calculate a percentage. This percentage represented the procedural integrity of the coaching in the TLE TeachLivE™ lab intervention phase.

***Social validity.*** Social validity was measured through a questionnaire completed by each participant (see Appendix C). Questions measured the perceived benefit of the intervention training on both the participant and their students. Additional questions addressed whether or not the participants intended to continue to use DTT in their classrooms, their level of comfort with DTT implementation, and their satisfaction with the training. A comment section was also included at the end of the questionnaire.

**Experimental Design and Data Analysis**

An ABC multiple baseline across participants design was used to assess participants' DTT implementation fidelity. First, baseline data were collected for all five participants beginning on the same day. Baseline data continued to be collected until there was a stable baseline with little or no trend (Kazdin, 2011) across a minimum of three data points for each participant so that one could confidently predict that the dependent variable (percent of DTT steps implemented correctly) would remain the same in constant conditions (Cooper, Heron, & Heward, 2007). Next, the intervention was applied for the participant who demonstrated the first stable baseline while baseline data continued to be collected for the other four participants. The DTTISC score for the four participants in baseline remained unchanged after the application of the intervention to participant one so the prediction was verified (Cooper et al., 2007). Once the level of responding in the first intervention phase (didactic training) for participant one was stable over three sessions, the independent variable was then applied to the second participant (Cooper et al., 2007) while the remaining three participants remained in the baseline phase. This process continued across all five participants. Participants entered the second intervention phase once they displayed a stable trend over three sessions (i.e., data points) in the first intervention phase. Intervention concluded during the second phase once the participant displayed a minimum of 85% fidelity of DTT implementation across three consecutive classroom observations.

The dependent variable for each participant (DTTISC score) was recorded and graphed during the course of the study to determine next steps. The graphs were visually inspected to analyze the level, trend, immediacy of change, mean, and non-overlapping data points.

**Advantages of multiple baseline designs.** There are several advantages to using multiple baseline designs. First, as is the case in single subject research, only one participant is necessary in multiple baseline designs across behaviors and settings. Even when multiple baseline designs across participants are used, only three to five participants are necessary. Second, no withdrawal of intervention is necessary to demonstrate the function of the intervention, so behavior does not need to be returned to baseline levels (Kazdin, 2011). In other words, one does not need to withdrawal an intervention that appears to be effective which is critical when dealing with severe self-injurious behaviors or aggression. This design can be used for behaviors that by their nature cannot be withdrawn such as irreversible behaviors where a skill cannot be unlearned. This design may also be more readily accepted in applied settings due to these reasons (Cooper et al., 2007).

Multiple baseline designs allow for the gradual application of intervention (Kazdin, 2011). In applied settings, staff other than the researcher are often applying the intervention, which may be difficult given their other duties and the considerable skill that may be required. Therefore, first implementing the intervention on a small scale (one behavior, setting, or individual) allows staff to proceed gradually and extend the intervention only after mastering the initial application. In addition, applying the intervention to only one behavior at a time allows a test of effectiveness. The preliminary effects can be examined before application to other behaviors, if the intervention is not particularly effective or the procedure is not implemented correctly it is useful to know this early on, prior to applying the intervention to other behaviors. Further, the gradual application of intervention follows the useful model of shaping, or gradually developing behaviors, as the changes are only required for one behavior at a time and once the individual improves, only then are the demands increased (i.e., requiring change in multiple behaviors; Kazdin, 2011). Sequentially applying the intervention complements the goal of practitioners in applied settings:  to develop multiple behavior changes. Teachers are required to help many children learn multiple skills and then generalize them to other settings, and clinicians frequently help individuals improve more than one behavior they must emit in multiple settings (Cooper et al., 2007).

Multiple baseline designs are feasible in applied settings for additional reasons. First, intervention is not withheld from a group for an extended period of time (i.e., the entire length of a study; Kazdin, 2011). Second, a large number of participants are not necessary. Third, it allows for decision making and subsequent changes based on the individuals performance during intervention as data is graphed and analyzed concurrent with the implementation of the intervention. For example, participants do not have to wait for the conclusion of the study to learn that the intervention was not effective, and additional components can be added or deleted from an intervention to maximize effectiveness (Kazdin, 2011). Finally, the concept is relatively easy for practitioners and parents to grasp, offering a practical and effective experimental method to individuals who are not formally trained in research methodology (Cooper et al., 2007).

Multiple baseline designs are useful in assessing generalization of behavior change (Cooper et al., 2007). This inherent assessment occurs because of concurrent measurement of two or more behaviors, settings, or individuals. Although this may decrease the ability of multiple baseline designs to demonstrate experimental control (i.e.

interdependence of behaviors), it has the potential to identify an intervention that is capable of changing behaviors with desirable generality (Cooper et al., 2007).

A final advantage of multiple baseline designs is the flexibility in which the intervention is applied. If some baselines are unstable or show a trend in a therapeutic direction, the intervention can be applied to a behavior that is stable and baseline can be continued for the other behaviors until a stable trend is displayed (Cooper et al., 2007; Kazdin, 2011).

**Disadvantages of multiple baseline designs.** Two major disadvantages of multiple baseline designs exist. First, it is weaker than a reversal design because experimental control is not shown by demonstrating change within the same behavior or individual (Cooper et al., 2007; Kazdin, 2011). In other words, the baseline prediction is verified with different behaviors (individuals) as opposed to the same behavior (individuals). Therefore, it must be inferred that the effect of the intervention is due to the lack of change in other behaviors (individuals). Second, multiple baseline designs may not allow demonstration of experimental control, even when a functional relationship between the independent variable and dependent variable exists due to potential cross over effects (Cooper et al., 2007; Kazdin, 2011).

A few other disadvantages exist with regards to multiple baseline designs. First, these designs provide more information about the effectiveness of the intervention than they do about the function of the target behavior (Cooper et al., 2007). In other words, it is more an experimental analysis of the technique used to alter the response than it is of the response itself. Second, the concurrent measures of multiple behaviors may be costly, particularly when the behavior must be observed and measured in multiple settings.

However, the use of intermittent baseline probes instead of continuous measurement can negate this disadvantage (Cooper et al., 2007).

**Multiple baseline designs impact on research.** These issues impact research in the area of autism spectrum disorders (ASD) in several ways. First, individuals with ASD exhibit unique strengths and needs, making it difficult to match participants for research purposes. Further, even though the current prevalence rate is 1 in 68 (Centers for Disease Control and Prevention, 2014) it is difficult to find large numbers of individuals with the diagnosis in the same geographic area. Second, severe self-injurious behaviors, aggression, and learned skills are common intervention targets for individuals with ASD. Therefore, multiple baseline designs are ideal for this population because no return to baseline, or withdrawal of intervention, is required to demonstrate a functional relationship between the intervention and target behavior. Second, interventions for students with ASD frequently take place in applied settings, such as schools. In 2009, there were 378,000 students receiving special education services in schools in the United States (USDOE, 2012). Therefore, it is important to have a research design that is readily accepted in schools. In multiple baseline designs the intervention does not need to be withdrawn so practitioners and parents are more likely to agree to participate. The gradual application of intervention makes it easier for practitioners and parents to implement, as extension of the skills to other behaviors (settings, individuals) occurs after the implementers have had time to master intervention procedures. If the intervention continues to be implemented incorrectly, corrections can take place before the intervention is applied to other behaviors or individuals. In addition, if the intervention is ineffective, changes can be made prior to the application to other individuals (settings, behaviors) in order to maximize effectiveness in a shorter amount of time. Finally, the concept of multiple baseline designs is relatively simple, making it easier to grasp for practitioners and parents compared to other research designs.

Multiple baseline designs directly impact the issue of generalization in students with ASD, as a typical characteristic of the disorder is the lack of skill generalization. In multiple baseline designs across settings and behaviors, the participant is required to generalize the target skill to other settings and behaviors. This inherent lack of skill transfer also decreases the likelihood of interdependence of baselines, a threat to internal validity.

# CHAPTER FOUR

# RESULTS

This chapter provides an overview of the results, including interobserver agreement, procedural fidelity, treatment outcomes, and social validity. This study sought to determine the effectiveness of a didactic training, and then individualized coaching in a virtual reality environment, TLE TeachLivE™, on special education teachers' implementation of DTT in their own classroom with students diagnosed with ASD. Finally, this study investigated the extent to which special educators were able to maintain their fidelity of implementation in their own classrooms across time. Specifically, this study addressed the following research questions:

1. How does a didactic training effect special educators' implementation of Discrete Trial Teaching (DTT) in their own classroom with students diagnosed with autism spectrum disorders (ASD)?
2. How does coaching in a virtual reality environment effect special educators' implementation of DTT in their own classroom with students diagnosed with ASD?
3. Can the results of these trainings (implementation of DTT with fidelity) be maintained by special educators' in their own classroom with students diagnosed with ASD over time?

An ABC multiple baseline across participants design was used to identify whether a functional relationship existed between the independent and dependent variables. Pseudonyms were used to protect participant confidentiality.

## Interobserver Agreement

The primary investigator collected all data for this study. Interobserver agreement (IOA) was provided by a fourth year doctoral student. A minimum of thirty percent of videos across all participants and phases were selected for IOA. Videos were randomly selected for IOA using an online random number generator. To ensure that 30% of videos were selected for each participant in each phase, a range of numbers was entered into the online random number generator by participant and phase. For example, participant one had five baseline observations, so the number range one through five was entered and the first three numbers in the output were used to select the videos used for IOA for the first participant's baseline phase (e.g., the number three represented the third baseline video). In another example, participant three had four classroom observations in the coaching phase. Therefore, the number range one through four was entered and the first two numbers in the output were used to select the videos used for IOA for participant four during the coaching phase. This process was completed for each participant for each phase. Total IOA across all participants and phases was 93.68% with a range of 85.7% to 100% (see Table 2 for averages for each participant by phase).

[Insert Table 2 here.]

## Procedural Integrity

The same doctoral student who provided IOA also viewed the coaching intervention videos for procedural fidelity. Fifty percent of videos across participants were selected for procedural integrity. Videos were randomly selected using an online random number generator. Total procedural integrity across all five participants was 100%.

## Treatment Outcomes

The Discrete Trial Implementation Steps Checklist (DTTISC) was used as the evaluation instrument during all phases of the study. Sixty-seven to 87 points could be earned on the DTTISC depending upon the number of correct student responses, therefore points were converted to a scale of 100%. Percentages of correct responses per session were calculated by dividing the number of correct steps by the total number of steps to determine the proficiency level of the special educator's DTT implementation.

### Research Question One

The first research question investigated in this study posed the query: How does a didactic training effect special educators' implementation of Discrete Trial Teaching (DTT) in their own classroom with students diagnosed with autism spectrum disorders (ASD)? Three participants demonstrated a slight increase in level with fidelity of DTT implementation over baseline after the didactic training. Three of the five participants demonstrated an immediate declining trend in their fidelity of DTT implementation from their first data point during this phase. One participant increased their fidelity of DTT implementation from the first to second classroom observation, but then their fidelity of DTT implementation decreased on the third observation, displaying an overall declining trend. One participant's fidelity of DTT implementation decreased from the first to second classroom observation, but then their fidelity of DTT implementation increased from the second to the third classroom observation but was still below the fidelity of the first observation, resulting in an overall declining trend. Figure 2 displays a graph of all five participants' fidelity of implementation over the course of the study. Table 3 displays participants' average scores and range of scores on the DTTISC for each phase and Table 4 displays participants' DTTISC scores in the TLE TeachLivE™ lab.

[Insert Figure 2 and Tables 3 and 4 here.]

**Megan**

The first participant, Megan, demonstrated a stable trend after the first observation in baseline. Her average baseline score was 56% correct implementation with a range of 54% to 61%. Megan displayed the most stable baseline of all participants and was therefore the first to enter the intervention phase. After the didactic training, Megan's fidelity of implementation increased slightly over baseline (from 55% to 66% correct), then displayed a declining trend over the next two observations (64% and 58%, respectively). Megan demonstrated an average of 62.67% during the first intervention phase, slightly above her highest score during baseline (61%).

**Layla**

The second participant, Layla, demonstrated a variable trend in baseline, with an overall declining trend after the first observation. A final baseline probe was taken just prior to her entering the first intervention phase to rule out any learning that may have taken place. Her average baseline score was 63.33% with a range of 42% to 77% correct. Layla demonstrated an increase in level from her final baseline probe to the first observation after the didactic training (75%). However, her first observation after the didactic training did not exceed her highest baseline point of 77%. Her second observation increased to 87%, but then her third observation dropped to 73% correct, below that of her highest score in baseline. Layla's average score during the first intervention phase was 78.33% correct, just slightly above her highest baseline probe (77%).

**Pamela**

The third participant, Pamela, demonstrated variability in baseline, with an overall increasing trend. Her average baseline score was 72.5% correct with a range of 68% to 80%. The final baseline probe taken just prior to her entering intervention was 68%. Pamela demonstrated an increase in level from her final baseline probe to the first observation after the didactic training (82%). However, her first observation after viewing the didactic training was only slightly above her highest baseline point of 80%. Pamela displayed a declining trend in the first intervention phase, with an average of 75% and a range of 69% to 82%. Her average score was just slightly above her baseline average of 72.5%.

**Juliette**

The fourth participant, Juliette, demonstrated an overall declining trend during baseline. Her average baseline score was 52.5% correct with a range of 36% to 69%. Her final baseline probe taken just prior to her entering the first intervention phase was a 61%. Juliette demonstrated a decrease in level from her final baseline probe to her first observation after the didactic training (61% to 58%). She then demonstrated a declining trend during this first intervention phase with an average of 52.33% (range of 48% to 58%), which was slightly below her baseline average of 52.5%.

**Kerry**

The fifth and final participant, Kerry, demonstrated an increasing trend over the first four baseline data points, then ended on a low point prior to the final probe. Her final baseline probe was similar to her average during the baseline phase. Her average during baseline was 68.17% correct, with a range of 48% to 78%. Her final baseline probe prior to entering the first intervention phase was 74%. After the didactic training, Kerry's observation score decreased in level from her final baseline probe (74% to 70%). She then demonstrated another decrease from her first to her second observation (70% to 59%) during this intervention phase and then displayed an increase in her score (69%). However, this slight increase remained below her final baseline probe and the first observation in this intervention phase. During the first intervention phase, Kerry demonstrated an average score of 66%, slightly below her average baseline score of 68.17%.

**Summary for Research Question One**

The objective of this research question was to determine the effect of didactic training on special educator's implementation of DTT in their own classroom with students diagnosed with ASD. The only variable that changed from baseline was that participants viewed a one-hour prerecorded PowerPoint training (i.e., didactic training) based on Fazzio and Martin's (2011) Self Instructional Manual. The average increase in level from participants' final baseline probe to the first point during the didactic training intervention phase was 10.2% with a range of -4% to 33%. Two of the participants scored lower in the first observation in the didactic training intervention phase as compared to their final baseline probe. The average increase from participants' baseline average to their average from the didactic training intervention phase was 4.37% correct (range -2.17% to 15%). Three of the participants displayed a declining trend after the didactic training. Participant two, Layla, showed an increase from the first observation to the second observation during intervention, then demonstrated a decreased from the second observation to the third observation where she scored lower than the first observation. Participant five, Kerry, decreased from the first observation to the second observation during intervention, then increased from the second observation to the third observation, but did not regain the level of the first intervention observation. However, all five participants displayed an overall declining trend line during this phase. In conclusion, as evidenced by the data, the didactic training was not sufficient to consistently bring participants to an acceptable fidelity level (at least 85%) with DTT implementation in their own classrooms with students diagnosed with ASD.

## Research Question Two

The second research question investigated in this research study posed the query: How does coaching in a virtual reality environment effect special educators' implementation of DTT in their own classroom with students diagnosed with ASD? All five participants demonstrated an immediate increase in level from their final observation in the didactic training intervention phase to their first observation after receiving coaching in the virtual reality environment, TLE TeachLivE™. In addition, all five participants demonstrated an increase in average from the first intervention phase (didactic training ) to the second intervention phase (coaching in a virtual reality environment). Only one participant, Pamela, required more than the minimum of three coaching sessions to reach the criteria of three sessions at or above 85% fidelity. Pamela required one more session, for a total of four coaching sessions in the virtual reality environment. See Figure 2 for a graph of all participants' observation data.

### Megan

The first participant, Megan, demonstrated a stable trend during the coaching intervention phase. She demonstrated a 39% increase in level from her last observation during the didactic training phase to her first observation after receiving coaching in a virtual reality environment (58% to 97%). Megan attended the virtual reality lab for the minimum of three coaching sessions as all of her classroom observation scores were above the criteria of 85% fidelity during this phase. Megan's average score in the coaching intervention phase was 96.67% correct with a range of 96% to 97%. In the TLE TeachLivE™ lab, Megan scored 95% and 100% on the DTTISC during the first session, 100% both times in the second session, and 99% and 100% during her third and final lab session, for an average score across all lab sessions of 99%. Megan's average increase from her baseline average to her average after receiving coaching in the virtual reality lab was 40.67%.

**Layla**

The second participant, Layla, demonstrated an increasing, then stable trend during the coaching intervention phase. She demonstrated a 14% increase in level from her last observation during the didactic training phase to her first observation after receiving coaching in a virtual reality environment (73% to 87%). Layla then scored 100% fidelity in the second and third observations, for an average of 95.67% during the coaching intervention phase (range of 87% to 100%). Layla attended the virtual reality lab for the minimum of three coaching sessions as all of her classroom observation scores were above the criteria of 85% fidelity during this phase. In the TLE TeachLivE™ lab, Layla scored 96% and 100% on the DTTISC during the first session, then 100% both times in the second and third sessions, for an average score across all lab sessions of 99.33%. Layla's average increase from her baseline average to her average after receiving coaching in the virtual reality lab was 32.34%.

**Pamela**

The third participant, Pamela, demonstrated an overall increasing trend during the coaching intervention phase. She demonstrated an 8% increase in level from her last observation during the didactic training phase to her first observation after receiving coaching in a virtual reality environment (69% to 77%). Pamela's average score in the coaching intervention phase was 91% correct with a range of 77% to 100%. As Pamela's first classroom observation score during this phase was below the 85% criterion, she attended a fourth coaching session in the virtual reality lab. In the TLE TeachLivE™ lab, Pamela scored 96% and 97% on the DTTISC during the first session, 100% and 99% during the second session, 100% both times in the third session, and 100% and 99% during her fourth and final session, for an average score across all lab sessions of 98.88%. Pamela's average increase from her baseline average to her average after receiving coaching in the virtual reality lab was 18.5%.

**Juliette**

The fourth participant, Juliette, demonstrated an increasing trend during the coaching intervention phase. She demonstrated a 44% increase in level from her last observation during the didactic training phase to her first observation after receiving coaching in a virtual reality environment (48% to 92%). Juliette's average score in the coaching intervention phase was 94% with a range of 92% to 96%. She attended the virtual reality lab for the minimum of three coaching sessions as all of her classroom observation scores were above the criteria of 85% fidelity during this phase. In the TLE TeachLivE™ lab, Juliette scored 81% and 95% on the DTTISC during the first session, then 100% both times in the second session, and 99% and 100% in the third session, for an average score across all lab sessions of 95.83%. Juliette's average increase from her baseline average to her average after receiving coaching in the virtual reality lab was 41.5%.

**Kerry**

The fifth participant, Kerry, demonstrated an overall increasing trend during the coaching intervention phase. She demonstrated a 20% increase in level from her last observation during the didactic training phase to her first observation after receiving coaching in a virtual reality environment (69% to 89%). Kerry's average score in the coaching intervention phase was 93% correct with a range of 89% to 97%. She attended the virtual reality lab for the minimum of three coaching sessions as all of her scores were above the criteria of 85% fidelity during this phase. In the TLE TeachLivE™ lab, Kerry scored 99% on the DTTISC both times during the first session, 100% and 99% during the second session, and 100% then 99% in the third session, for an average score across all lab sessions of 99.33%. Kerry's average increase from her baseline average to her average after receiving coaching in the virtual reality lab was 24.83%.

**Summary for Research Question Two**

The objective of the second research question was to determine the effect of coaching in a virtual reality environment on special educators' implementation of DTT in their own classroom with students diagnosed with ASD. The variables that changed from the previous didactic training intervention phase were the presence of coaching and immediate practice within a virtual reality lab with a student avatar who displayed mild behavioral characteristics associated with ASD such as inattention, body rocking, and hand flapping. The average increase in level from participants' final didactic training observation to the first point after receiving coaching in the virtual reality environment was 25% with a range of 8% to 44%. The average increase from participants' didactic training average to their average after receiving coaching in the virtual reality lab was 27.2%, with a range of 16% to 41.67%. The average increase from participants' baseline average to their average after receiving coaching in the virtual reality lab was 31.57% with a range of 18.5% to 41.5%. In conclusion, as evidenced by the data, coaching in the virtual reality lab was sufficient to bring participants to an acceptable fidelity level (85%) with DTT implementation in their own classrooms with students diagnosed with ASD. In fact, all participants reached at least 96% fidelity during at least one observation after receiving coaching in the virtual reality lab. Two of the five participants reached 100% implementation fidelity in their classrooms with students diagnosed with ASD after receiving coaching in the virtual reality lab.

## Research Question Three

The third research question investigated in this study posed the query: Can the results of these trainings (implementation of DTT with fidelity) be maintained by special educators' in their own classroom with students diagnosed with ASD over time? Due to school closings for holidays and weather, maintenance probes ranged from two weeks to eight weeks. All five participants demonstrated an acceptable level of fidelity (85%) during all maintenance probes. In fact, all five participants demonstrated an average of at least 90% level of fidelity. In addition, three of the five participants' average fidelity of implementation actually increased from the last intervention phase, coaching in the virtual reality lab, to the maintenance phase. See Figure 2 for a graph of all participants' observation data.

### Megan

The first participant, Megan, maintained her implementation fidelity during the maintenance phase, demonstrating acceptable implementation fidelity (85%) during all three maintenance probes. Megan's maintenance probes were taken at two, four, and six weeks. Her average implementation fidelity during this phase was 95.33% correct, with a range of 91% to 99%.

**Layla**

The second participant, Layla, maintained her implementation fidelity during the maintenance phase, demonstrating acceptable implementation fidelity (85%) during all three maintenance probes. Layla's maintenance probes were taken at two, four, and eight weeks. Her average implementation fidelity rate during this phase was 100% correct, with all three probes at the 100% fidelity. She demonstrated a 4.33% incline from her average fidelity during the last intervention phase to her average fidelity during maintenance.

**Pamela**

The third participant, Pamela, maintained her implementation fidelity during the maintenance phase, demonstrating acceptable implementation fidelity (85%) during all three maintenance probes. Pamela's maintenance probes were taken at two, six, and eight weeks. Her average implementation fidelity during this phase was 90.33% correct, with a range of 86% to 94%.

**Juliette**

The fourth participant, Juliette, maintained her implementation fidelity during the maintenance phase, demonstrating acceptable implementation fidelity (85%) during all three maintenance probes. Juliette's maintenance probes were taken at two, five, and seven weeks. Her average implementation fidelity during this phase was 97.67% correct, with a range of 94% to 100%. She demonstrated a 3.67% increase from her average fidelity during the last intervention phase to her average fidelity during maintenance.

**Kerry**

The fifth participant, Kerry, maintained her implementation fidelity during the maintenance phase, demonstrating acceptable implementation fidelity (85%) during all three maintenance probes. Kerry's maintenance probes were taken at four, six, and eight weeks. Her average implementation fidelity during this phase was 97.33% correct, with a range of 96% to 100%. She demonstrated a 2.062% increase from her average fidelity during the last intervention phase to her average fidelity during maintenance.

**Summary for Research Question Three**

The objective of the third research question was to determine the effect of the trainings on special educators' implementation of DTT in their own classroom with students diagnosed with ASD. The average change from participants' last intervention phase to the maintenance phase was an increase of 2.062%, with a range of -1.34% to 4.33%, as three of the five participants' averages increased during the maintenance phase. The average change from participants' baseline to the maintenance phase was an increase of 33.63%, with a range of 17.83% to 45.17%. All maintenance probes were above the determined rate of acceptable fidelity of 85%, with a minimum participant average of 90.33%. In conclusion, as evidenced by the data, didactic training followed by coaching in a virtual reality lab, TLE TeachLivE™, was sufficient in maintaining participants' fidelity levels at the predetermined acceptable rate of 85% with DTT implementation in their own classrooms with students diagnosed with ASD for up to eight weeks after receipt of intervention.

## Social Validity

After conclusion of the maintenance phase, participants were administered a social validity questionnaire consisting of seven Likert-type scale questions and one open-ended question. All responses remained anonymous. See Table 5 for a summary of the participants' answers. In response to the statement, "Using evidence-based practices is important when working with students with Autism Spectrum Disorder (ASD)" 80% strongly agreed and 20% agreed. Sixty percent of participants agreed (40% strongly agreed) with the following statement: "Discrete Trial Teaching (DTT) is useful when working with students with ASD." Sixty percent of participants strongly agreed and 40% of participants agreed with this statement: "The TLE TeachLivE™ lab was a good environment in which to learn DTT Implementation." In response to the statement, "The PowerPoint presentation was helpful in increasing the accuracy with which I implement DTT" 80% of participants agreed and 20% were neutral. Eighty percent of participants strongly agreed while 20% agreed with the following statement: "The individualized coaching was helpful in increasing the accuracy with which I implement DTT." Sixty percent of the participants agreed and 40% strongly agreed with the statement: "Working with Austin, the student avatar, made it easy to transfer what I learned in the lab to working with my own students with ASD in my classroom." In response to the statement, "I plan to continue to use DTT with my students with ASD" 60% of participants strongly agreed and 40% agreed. Two participants left additional comments: "This was a great learning experience! I really enjoyed working with Austin in the TLE TeachLivE™ Lab.

I have been able to apply what I learned during the study into the classroom when I work 1:1 with my students.” and “Thank you so much!” These remarks are similar to those reported in early computer simulation research (Flake, 1973; Lloyd & Idol-Maestas, 1983) as well as those reported in previous research using TLE TeachLivE™ (Vince-Garland, 2012). Participant answers demonstrated that coaching within TLE TeachLivE™ was a socially valid intervention.

[Insert Table 5 here.]

# CHAPTER FIVE

# DISCUSSION

This chapter provides a discussion of the study, including the rationale and purpose, and the results for each of the three research questions in conjunction with methodological and applied implications. This study's limitations and delimitations are then discussed, followed by future directions, and an overall conclusion. A quantitative synthesis was not used to answer any of the three research questions as this methodology (i.e., percentage of nonoverlapping data, pairwise data overlap squared, percentage of data exceeding the median, and percentage of data exceeding a median trend) has been found inappropriate for summarizing single-subject research data (Wolery, Busick, Reichow, & Barton, 2010).

## Purpose of the Study

Students identified with ASD are in the fastest growing disability category receiving special education services in schools (Ludlow, Keramidas, & Landers, 2007) with a current prevalence rate of 1 in 68 children in the United States, a 30% increase since 2012 (Centers for Disease Control and Prevention, 2014). Teachers of students with ASD and other disabilities are encouraged by law (NCLB, 2002) and professional standards (Council for Exceptional Children, 2009) to use evidence-based practices (EBPs). In order to be effective, special educators must be knowledgeable about and able to implement EBPs that address disability-specific needs so they can provide intensive, explicit instruction within the broader general education curriculum (Brownell et al., 2010). Unfortunately, not only are many teachers unaware of EBPs, they have not mastered the few practices that they are familiar with to the level that is required to impact student learning (Scheuermann et al., 2003). The strongest link between EBPs and positive student learning outcomes is instruction with fidelity of implementation (Vince-Garland et al., 2012).

Both the National Professional Development Center on ASD and the National Autism Center identified Discrete Trial Teaching (DTT) as an effective EBP for students with ASD (NAC, 2009; Wong et al., 2014). DTT uses small repetitive steps to teach concepts in a planned, controlled, systematic one-to-one format where educators pair positive reinforcement with clear contingencies and repetition to teach a variety of new skills (Ghezzi, 2007).

One training method that has been recognized as an evidence-based practice for training practitioners is coaching (Parsons et al., 2012). The purpose of coaching is to provide support, encouragement, and technical feedback in order to assist teachers in the transference of skills from training to the classroom (Showers, 1982) and translating research into practice (Knight, 2009). As the National Council for Accreditation of Teacher Education (NCATE, 2010) stated, technology must be incorporated to facilitate ongoing professional learning; coaching with technology offers teacher educators an effective medium by which coaching can take place without interrupting instruction for students (Guralnick & Levy, 2009; Scheeler et al., 2012).

Coaching in computer-simulated environments offers one method of training teachers in the area of EBPs without practicing on actual students. Computer simulation provides users with a realistic learning context in which they can interact with and gain insight into a real world process or event through active learning (Cruickshank & Telfer, 1980; Lee, 1999). In addition, computer-simulated environments encompass carefully designed scenarios and situations created to target key learning points, providing the opportunity for accelerated learning by ensuring the user encounters specific situations (Cruickshank, 1969; Guralnick & Levy, 2009). Learning is enabled across domains and skill transfer increases when well-constructed virtual reality environments are utilized as the user's input affects the output and in turn the user's simulation experience (Cruickshank, 1969; Hayes et al., 2013). One virtual reality environment that has demonstrated through research the capacity to prepare teachers in a classroom environment is TLE TeachLivE™ (Myers et al., 2010; Vince-Garland, 2012; Vince-Garland et al., 2012). Therefore, the current study sought to determine the effectiveness of a didactic training, and then the addition of individualized coaching in a virtual reality environment, TLE TeachLivE™, on special education teachers' implementation of DTT in their own classroom with students diagnosed with ASD. Finally, this study investigated the extent to which special educators were able to maintain their fidelity of implementation in their own classrooms over time.

**Research Question One**

*How does didactic training effect special educators' implementation of Discrete Trial Teaching (DTT) in their own classroom with students diagnosed with autism spectrum disorders (ASD)?*

The only variable that changed from baseline to the first intervention phase (didactic training) was that participants viewed a one-hour prerecorded PowerPoint presentation based on Fazzio and Martin's (2011) Self Instructional Manual. The participants' implementation of DTT was then measured in their classrooms. The mean increase from participants' baseline average to their average in the didactic training intervention phase was 4.37% correct (range -2.17% to 15%). Three of the five participants demonstrated an increase in level from their last baseline probe to their first data point after the didactic training while the remaining two participants demonstrated a decrease in level. In addition, all five participants displayed an overall declining trend during this phase. Based on these data, didactic training was not sufficient for participants' to reach an acceptable level of fidelity of DTT implementation (at least 85%). In addition, this intervention was not sufficient to maintain the level of fidelity that participant's did achieve for more than one to two days as evidenced by the declining trend across the phase displayed by all five participants. These results were similar to findings by Kretlow and colleagues (2009) where in-service training was delivered via a PowerPoint presentation resulting in teaching improvements after the in-service, but variable performance remained and did not exceed 80% correct. This pattern was demonstrated even though the in-service also incorporated live and video demonstrations along with the opportunity to practice in teacher pairs and receipt of feedback from the researcher (Kretlow et al., 2009). Likewise, Kretlow and colleagues (2012) found that while participants' teaching strategies improved after an in-service, performance remained low and inconsistent. Similarly, Suhrheinrich (2011) found that only three out of 20 educators mastered all teaching components after an in-service that consisted of didactic instruction, video and in-vivo modeling, trainer feedback, and a discussion of implementation techniques and questions. The didactic training in the present study replicated a typical professional development or in-service experienced by special educators. These results are consistent with previous research as it demonstrates typical professional development activities experienced by educators do not provide sufficient training (Knight, 2009; Kretlow & Bartholomew, 2010; Yoon et al., 2007). The current study extends previous research by demonstrating that special educators with prior DTT instruction who still do not demonstrate acceptable implementation fidelity with an evidence-based practice, DTT, require more training than a typical professional development offers, to raise consistently their implementation fidelity to acceptable levels.

**Research Question Two**

*How does coaching in a virtual reality environment effect special educators' implementation of DTT in their own classroom with students diagnosed with ASD?*

The variables that changed from the previous didactic training intervention phase were the presence of coaching, brief modeling, and immediate practice within a virtual reality environment with a student avatar who displayed mild behavioral characteristics associated with ASD such as inattention, body rocking, and hand flapping. All five participants reached an acceptable level of fidelity of DTT implementation (at least 85%) during the first lab session. Further, all five participants reached a perfect implementation fidelity score of 100% by the second lab session. In fact, two of the five participants reached a perfect implementation fidelity score of 100% during the first lab session. Based on these data, just one 45-minute session of coaching in a virtual reality lab was sufficient to bring participants to an acceptable level of fidelity of DTT implementation (at least 85%) when implementing DTT with a student avatar. The first TLE TeachLivE™ lab session was approximately 45 minutes in length, which was shorter in duration than the didactic training (i.e., one hour Powerpoint presentation). Therefore, less training time was necessary using the TLE TeachLivE™ lab and coaching as compared to traditional professional development for participants' to achieve an acceptable level of fidelity of DTT implementation. These findings are similar to that of early computer simulation research in that only a brief time period within the simulated environment is necessary for participants' to demonstrate significant gains. For example, Strang and colleagues (1987) found that inexperienced education students made significant improvements in their behavior management skills, to the point that they no longer demonstrated a significant difference from the experienced teachers, after only two 20-minute sessions. These data also support the statement made by Dieker and colleagues (2014) that using the TLE TeachLivE™ virtual reality environment is a faster way to train educators.

All five participants demonstrated an substantial change in level during classroom observations from the final data point in the didactic training phase to the first data point in the coaching in a virtual reality environment phase, which took place after one 45-minute session of coaching in the virtual reality environment. The average increase in level from participants' final observation in the didactic training phase to the first classroom data point after receiving coaching in the virtual reality environment was 25% (range 8% to 44%). Similar to the study completed by Sarokoff and Sturmey (2004), the current study demonstrated that special educators' exhibited high implementation fidelity in their classrooms with students with ASD immediately after one training session. However, in the study by Sarokoff and Sturmey (2004) the special educators received coaching while working with a student with ASD and not a student avatar. Therefore, these results demonstrated that generalization to new tasks and new students occurs immediately after acquiring initial high rates of fidelity when working in a virtual reality environment, and special educators need not wait until they reach consistent high rates of fidelity in training before implementing the EBP with students. In other words, participants' were able to transfer immediately the skills learned in the TLE TeachLivE™ lab with the student avatar to their own classrooms with students diagnosed with ASD. These results support previous statements that computer-simulated environments facilitate the transfer of knowledge and skill from one setting to another and from acquisition to application (Cruickshank & Telfer, 1980; Dieker et al., 2014; Myers et al., 2010; Strang, 1990; Strang & Clark, 2003).

Participants' mean scores increased from both the didactic training intervention phase and the baseline phase after the receipt of coaching in the virtual reality environment. The average change across all participants from the didactic training intervention phase to the coaching in the virtual reality lab was 27.2% (range 16% to 41.67%). The mean change across all participants from baseline to the coaching in the virtual reality lab was 31.57% with a range of 18.5% to 41.5%. All five participants reached at least 96% fidelity during one classroom observation after receiving coaching in the virtual reality lab. Two of the five participants reached 100% implementation fidelity in their classrooms with students diagnosed with ASD after receiving coaching in the virtual reality lab. Therefore, as evidenced by the data, coaching in the virtual reality lab was sufficient to bring participants to an acceptable fidelity level (at least 85%) with DTT implementation in their own classrooms with students diagnosed with ASD. These results replicated those of previous research (Kretlow et al., 2009; Kretlow et al., 2012; Suhrheinrich, 2011) where educators first attended an in-service training, but only made consistent, substantial gains in implementation fidelity after the receipt of coaching.

The current study incorporated three essential attributes of computer simulations and three powerful learning principles as described by Strang and colleagues (1989). First, Austin the student avatar responded to the special educator in a variety of ways including pointing, inattention, rocking, flapping, and noise making. Second, Austin immediately responded to the teacher's directions to attend. Third, Austin responded accurately when the special educator provided proximity prompts following an incorrect response. In addition, coaching within TLE TeachLivE™ incorporated three powerful learning principles: practice, reinforcement, and feedback (Strang et al., 1989). The participants were able to engage in multiple teaching attempts (practice), were reinforced by Austin's compliance and accurate responding after assistance was provided (reinforcement), and correct responses were confirmed while errors were identified by the coach (feedback). Therefore, the current study combined essential attributes of computer simulations with powerful learning principles described in previous research, which resulted in an effective coaching intervention within a virtual reality environment.

Similarly, the current study encompassed other critical factors identified in previous research. Taken together, two different reviews of studies utilizing computer simulations demonstrated three key factors contributed to positive results: immediate feedback provided both intrinsically (via correct student responses and compliance) and extrinsically (via coaching), an enjoyable experience, and the realism of the encounter (Lee, 1999; Thomas & Hooper, 1991). Both intrinsic and extrinsic feedback was provided to participants in the current study within the virtual reality environment through the communication of specific objectives to both the participants and the interactors. This clear communication prepared the participants for the carefully controlled practice session within TLE TeachLivE™ in which the student avatar (interactor) reacted in a manner that provided appropriate intrinsic feedback to the participant in order to assist them in reaching the specified objective. Unlike the study conducted by Myers and colleagues (2010), extrinsic feedback was provided upon completion of 10 DTT trials instead of pausing the simulation in the middle of the participant conducting the trials. Although Myers et al. (2010) discussed the pros of being able to pause the classroom avatars in order to coach the teachers unobtrusively, they did not compare this method to one in which feedback was provided by a coach immediately after the session. The current results suggest that pausing the simulation to provide feedback immediately after 10 DTT trials is sufficient instead of pausing the simulation in the middle of the DTT session. Similar to providing participants with a personalized experience they believe is real (Dieker et al., 2014), another critical component of effective computer simulations is the suspension of disbelief. The suspension of disbelief occurs when there is a high level of engagement between the user and the technology (Dede, 2009). Similar to previous research (Elford et al., 2013; Vince-Garland, 2012) participant comments during the study and on the social validity questionnaire demonstrated they enjoyed the experience and felt the interactions within TLE TeachLivE™ were realistic, indicating a suspension of belief was present.

Additionally, the current study placed the emphasis on the educational components instead of the simulation itself, a prerequisite for users to reap the educational benefit of computer-simulated environments (Cruickshank & Telfer, 1980; Guralnick & Levy, 2009). The researcher ensured the emphasis was on the educational components by carefully creating situations that provided specific learning objectives, feedback, and support (Guralnick & Levy, 2009; Thomas & Milligan, 2004). Having a defined scope and sequence clearly describing the specific objectives was also described by Myers and colleagues (2010) as a necessary component to the effectiveness of the TLE TeachLivE™ technology. Likewise, Myers et al. (2010) cited the necessity of an introduction to the technology for the participants and clear succinct coaching skills as critical components contributing to the effectiveness of the TLE TeachLivE™ environment. As suggested by Myers and colleagues (2010) and Vince-Garland (2012), the participants in the current study were exposed to the TLE TeachLivE™ environment via an introductory session prior to the beginning of the study. Succinct coaching skills (e.g. when to provide error correction and feedback) were demonstrated in the current study via procedural integrity.

Likewise, the current study encompassed the cyclical process, a critical component in grounding the impact of computer-simulated environments in behavior (Dieker et al., 2014). By having a clear objective for the observation and a debriefing on observed behaviors after the observation, the current study allowed the special educators to self-reflect, ask questions, and receive coaching (Dieker et al., 2014). Although previous research has reported technical difficulties as one barrier to using virtual reality environments (Moizer et al., 2009; Vince-Garland, 2012), the current study encountered no major technical difficulties with TLE TeachLivE™. In addition to encompassing key factors in computer-simulation, the current study also used previous research on coaching to ensure the inclusion of effective components.

The current study incorporated seven of the effective coaching components discussed by Knight (2009). First, the coaching focused on professional practice (i.e., improving student education by refining educator's teaching methods). Second, participants were able to immediately apply the methods in both the virtual reality environment and then in their classrooms the following day. Third, coaching was provided in an intensive, differentiated one-to-one format that lasted three or more days where feedback was based on observational data (Knight, 2009; Kretlow & Bartholomew, 2010; Miller et al., 1991). A direct statement of strengths in addition to omissions, material arrangement, and the cohesiveness of the teaching strategy were discussed to ensure the continuation of growth in the classroom (Kretlow & Bartholomew, 2010; Showers, 1982). Fourth, the coach's role was that of a collaborator in an equal partnership with the special educators as opposed to an administrative figure. Fifth, the coach was non-evaluative and discussions remained non-judgmental (Knight, 2009, Showers, 1982). Sixth, special educators' were able to openly discuss their strengths and concerns as they remained confidential. Finally, the coach exhibited excellent communication skills, articulating clear messages and listening respectfully in an energizing, encouraging, practical, and honest manner. These seven effective components identified by Knight (2009) played a critical role in the effectiveness of the coaching in the current study.

In addition to the seven effective coaching components, the current study also incorporated five of the necessary conditions to enable successful coaching identified by Knight (2009). First, coaching was focused and continuous as the objectives were clear and coaching lasted several days. Second, by providing praise throughout each session, the coach created a learning-friendly culture in which the special educators felt respected and free to take risks and learn. Third, the current study was supported by the KKI school administration. Fourth, the coach did not perform any administrative duties within KKI or the school where the special educators' taught. Finally, sufficient time was provided for coaching at the end of the special educator's school day once the student's left, so they were not required to work beyond their regularly scheduled times (Knight, 2009). In addition, this study provided participants with guided practice in the form of multiple response opportunities in which special educators' were actively engaged (Kretlow & Bartholomew, 2010). The presence of these conditions played an important role in the effectiveness of the coaching intervention in the current study.

Coaching in the current study consisted of verbal and written feedback, modeling of consequence management (only when consistent errors were observed), and then an uninterrupted practice session of 10 DTT trials. These results extend previous research (Sarokoff & Sturmey, 2004) by demonstrating that providing graphed performance data, modeling full DTT trials, and a brief rehearsal period after providing verbal feedback is not necessary prior to the second practice session (i.e., special educator's implementation of 10 uninterrupted DTT trials) for special educators to reach high implementation fidelity with DTT. In addition, Nosik and colleagues (2013) concluded that a behavior skills training package consisting of a PowerPoint training, modeling of DTT with a student confederate, and general feedback during practice was more effective than computer-based instruction in improving participants' accuracy of DTT implementation. This study extends those findings by demonstrating that a didactic training (i.e., PowerPoint presentation) alone is not effective in improving fidelity of implementation of DTT. Further, the combined results of Nosik et al. (2013) and the current findings may indicate that the rehearsal component (included in only the behavior skills training and not the computer-based instruction) was the critical component necessary for special educators' to reach implementation fidelity with DTT. The current study also extends previous research (Myers et al., 2010; Vince-Garland et al., 2012) by demonstrating that a full modeling component of a DTT trial is unnecessary, as the modeling was only provided when participants made consistent mistakes with error correction. These are significant findings as these components can consume unnecessary lab time as well as the time of the coaches and special educators. Similar to the findings of Kretlow and Bartholomew (2010), this study demonstrated substantial improvements in implementation fidelity of an EBP after just a few coaching sessions, which contrasts the results found by Vince-Garland et al. (2012).

**Research Question Three**

*Can the results of these trainings (implementation of DTT with fidelity) be maintained by special educators' in their own classroom with students diagnosed with ASD over time?*

Similar to Miller et al. (1991), the DTTISC was not reviewed with the participant's prior to the maintenance observations, but the special educator's knew when the researcher was coming to observe. The average change from participants' last intervention phase to the maintenance phase was an increase of 2.062% (range -1.34% to 4.33%), as three of the five participants' means increased during the maintenance phase. Similar to previous research (Elford et al., 2013) these results suggest that continued learning takes place after coaching and feedback as the special educators' implemented DTT with students in their classrooms beyond the three classroom sessions during the coaching phase. The average change from participants' baseline to the maintenance phase was an increase of 33.63%, with a range of 17.83% to 45.17%. All maintenance probes were above the determined rate of acceptable fidelity of 85%, with a minimum participant average of 90.33%. In conclusion, as evidenced by the data, didactic training followed by coaching in a virtual reality lab, TLE TeachLivE™, was sufficient in maintaining participants' fidelity levels at the predetermined acceptable rate of at least 85% with DTT implementation in their own classrooms with students diagnosed with ASD up to eight weeks after receipt of intervention.

## Limitations

A few limitations exist within this study. First, a small sample size of five participants limits the generalizability of the findings. In addition, the five participants were all special educators' in a nonpublic school setting so the findings may not generalize to special educators in public or private school settings with larger class sizes who may be unable to devote the time necessary for working one-on-one with a student. Second, similar to Kretlow et al. (2009), it is unknown if the video recording had an impact on the participant's implementation fidelity. In other words, the participant's may not have been conducting DTT with high implementation fidelity during other instructional times when they were not being observed or video recorded. Third, the current study did not control for task variety during the classroom observations as the special educators' used the tasks their students were currently working on as part of their Individualized Education Program. Fourth, the only student characteristic controlled for in the current study was the diagnosis of ASD. Other characteristics varied by student such as academic level, secondary diagnoses, communication level, and interfering behaviors. Not controlling for student characteristics or task variety increases the generalizability but could have resulted in the individual teacher's score fluctuations. Fifth, the current study did not separate the effects of the didactic training from the effect of the coaching within TLE TeachLivE™. Therefore, although it appears the didactic training was not sufficient in and of itself to train special educators' to fidelity with DTT, we cannot separate the effects of the two trainings combined. The only valid conclusion that can be made is that coaching in a virtual reality environment following didactic training was sufficient in training special educators' to fidelity with DTT. Finally, the current study did not compare training with a student confederate to training with a student avatar. Therefore, it remains unknown how exactly training with a student avatar differs from training with a student confederate in the acquisition of an EBP, such as DTT, to fidelity.

**Delimitations**

Several limitations exist within single subject multiple baseline designs. Threats to internal validity exist such as interdependence of baselines, inconsistent intervention effects on different baselines, and prolonged baselines (Kazdin, 2011). The interdependence of baselines, or cross-over effects, were not demonstrated in the current study. In other words, participant behaviors did not change in baseline, behaviors only changed once the intervention was applied. To avoid cross-over effects, participants received didactic training and received coaching within the virtual reality lab on an individual basis. In addition, participants taught in different classrooms and did not observe one another during the course of the study. Therefore, clear intervention effects were present in the current study. Although consistent intervention effects were not displayed across participants in the first intervention phase (didactic training), a minimum of two participants did display both an increase (Megan, Layla, and Pamela) and decrease (Kerry and Juliette) in level from baseline to the didactic training phase. In addition, all five participants displayed an overall declining trend during this phase. Therefore, the conclusion can be made that didactic training was not an effective training modality for special educators' to consistently increase their fidelity levels of DTT implementation to an acceptable rate of at least 85%. Prolonged baselines, or withholding the intervention from participants' can be a threat to internal validity as well as an applied and ethical consideration. The fourth participant, Juliette, remained in baseline for five weeks and the final participant, Kerry, remained in the baseline phase for six weeks. However, low implementation fidelity during final baseline probes ruled out prolonged baselines as a threat to internal validity in the current study. Although, applied and ethical considerations still remain as the special educators continued implementing DTT with low levels of fidelity during baseline, which may have affected student outcomes. However, this concern is not unique to multiple baseline designs or single subject research as the same issues could be raised with any type of experimentation where the intervention is withheld or is of unknown effectiveness (Kazdin, 2011).

It is true that single subject research does not use random sampling, which presumably would allow the findings to generalize to the population in which the sample was drawn. However, true random sampling is rarely achieved (Kazdin, 1981). Therefore, "the absence of a completely random sample need not delimit the generality of findings (Kazdin, 1981, p. 134)." Birnbrauer (1981) holds the view that single subject studies cannot make predictions about populations and that is not their intention; they are intended to make predictions regarding intervention effectiveness given functional similarities between baseline conditions and behavior. However, Kazdin (1981) states that generalization depends on both the similarities of the participant(s) to the population and the relevance of any differences of the participant(s) and the population with respect to the variables under investigation. Therefore, random sampling and large numbers of participants are not necessary for generalization. In contrast, generalizability can be enhanced through the intentional selection of participants, either because they represent a heterogeneous sample or because they are 'typical' participants. Further, in single subject designs, external validity can be increased by including participants who have been resistant to interventions, therefore providing an even stricter test for the intervention (Kazdin, 1981). In the current study, the participants represent a heterogeneous sample of special educators with small class sizes who have been resistant to previous DTT training. Both Kazdin (1981) and Birnbrauer (1981) agree that replication research substantially enhances generalizability. Generality is established by accumulating internally valid studies, in turn placing the results in systematic context (Birnbrauer, 1981). Therefore, it is essential to operationally define and describe in sufficient detail the participants, setting, baseline, intervention, and assessments to allow for replication (Horner, Carr, Halle, McGee, Odom, & Wolery, 2005). Kazdin (1981) further posits that single subject research findings are highly generalizable due to the interventions commonly investigated. DTT is a commonly investigated intervention and the current study operationally defines and describes the participants, setting, assessments and interventions, allowing for replicability.

One of the major threats to construct validity in single subject research, which extends to multiple baseline designs, is the attention and contact accorded to the client

(Kazdin, 2011). For example, during baseline the participant may not receive attention, then when intervention begins, the participant is provided with increased attention, contact, monitoring, and/or feedback. It may in fact just be the increased attention that is responsible for the change, not the intervention itself, a type of placebo effect. Attention and contact are threats to validity only if they are plausible explanations. If the purpose is to conclude why the intervention was successful, these confounding variables should be ruled out by a phase in the design (Kazdin, 2011). The purpose of the current study was to demonstrate the effectiveness of the intervention, not the reason why it was effective.

Another major threat to construct validity in single subject research, including multiple baseline designs, is special conditions, settings, and contexts (Kazdin, 2011). These features may be seemingly irrelevant, but can introduce ambiguity when attempting to interpret the results. As with attention and contact, this is only a threat if the purpose is to conclude which aspect of the intervention, or a seemingly irrelevant feature, is responsible for the effects (Kazdin, 2011). In the current study, the coach had fifteen years of experience implementing DTT as well as experience providing individualized coaching to special educators in school settings, which may be responsible for the effects. However, other studies have had similar outcomes when coaches with experience provide the intervention to educators (Bethune & Wood, 2013; Kretlow et al., 2009; Kretlow et al., 2012; Sarokoff & Sturmey, 2004; Suhrheinrich, 2011). Therefore, replication of previous findings adds to the construct validity of using TLE TeachLivE™ for training teachers as a different coach provided the feedback, demonstration, and facilitated practice in the current study.

In single subject designs, including multiple baseline designs, threats to data-evaluation validity are present (Kazdin, 2011). Data-evaluation threats occur when aspects of the data interfere with drawing valid inferences. First, excessive variability in the data can obscure any intervention effects as single subject research typically relies on visual analysis to interpret patterns in the data. If excessive fluctuation in the data exists, within or across phases, patterns in the data cannot be reliably detected. Variability can come from a variety of sources including uncontrolled setting influences that vary widely every day, unreliability of the measurement tool, inconsistent intervention implementation, differences among participants, and cycles or abrupt changes within the participant (e.g. medicine in-take) or environment (e.g. changes in classroom routines).

The case of unreliability of the measurement tool warrants further discussion. If the measurement tool/system being used is unreliable, then assessment of target characteristics is inconsistent (Kazdin, 2011). Some degree of fluctuation is expected as the individual undergoes competing influences (e.g. mood, context, prior interactions). Minimizing extra, unsystematic variation reduces the likelihood of unnecessary fluctuations in behaviors. When fluctuations that result from the measurement system interfere with interpretation of the data, unreliability of the measurement tool is a threat to data-evaluation validity. However, this threat is not unique to single subject designs, as even standardized assessments do not have a fixed reliability; they can vary as a function of conditions of administration, sample, and use. The use of automated or mechanical equipment can increase reliability, but are often not used as the measurement tool in single subject designs (Kazdin, 2011). Although some fluctuation in scores was present in the current study, overall trends in the data remained consistent.

Another threat to data-evaluation validity is trends in the data, or the slope of change over time (Horner et al., 2005; Kazdin, 2011). As multiple baseline designs, and single subject research in general, rely on the visual analysis of trend line slope to determine the effectiveness of an intervention, clear evaluation is critical. In some cases, the slope of the trend line during baseline may indicate a therapeutic effect, potentially causing the change from baseline to intervention to be masked. In contrast, the slope of the trend line could represent a deterioration in behavior during intervention. When the trend line obscures the effect of the intervention or makes it difficult for inferences to be drawn, a threat to data-evaluation is present. Likewise, if data are insufficient to characterize performance and to provide a reliable prediction of future performance it poses a threat to data-evaluation validity (Kazdin, 2011). In the current study, individual percentages of implementation fidelity were graphed for each observation, not trend lines. In addition, the minimum of three data points per phase were used in order to provide a reliable prediction of future performance.

Where variable trends in the data were noted in the current study, an overall trend line slope was calculated using the Microsoft Excel trend line function. Further, variable trends were only noted in two of the participants during the didactic training phase, and both participants demonstrated an overall declining trend during this phase. Therefore, threats to data-evaluation validity were ruled out.

Mixed data patterns are also a threat to data-evaluation validity as they can interfere with the evaluation of data (Kazdin, 2011). It is important to have consistency in the data in order to make accurate interpretations and draw inferences. If a mixed data pattern occurs, it interferes with the inferences able to be drawn regarding the intervention. Any of the previously mentioned threats to data evaluation could be the cause of a mixed data pattern. Another cause is the inherent differences between individuals in a multiple baseline across participants design, the more diverse the participants, the greater possibility of varying responses to intervention. However, typically strong interventions reduce variability, in turn alleviating the possibility of threats to data-evaluation (Kazdin, 2011). Again, mixed data patterns were only present for two of the participants during the didactic training phase. However, when overall trend lines were calculated within Microsoft Excel, a declining trend was demonstrated.

**Future Directions**

This study raises several questions for future research, including research to address the limitations discussed. First, the participants in this study were practicing special educators in a nonpublic school setting with an average of 2.8 years of teaching experience. Future research could include pre-service and in-service general and special educators in a variety of settings, including private and public school settings, as these settings typically have larger class sizes. Larger class sizes may impede special educators' ability to work effectively one-on-one with a student. Second, this study could be replicated using different coaches to ensure the success of the interventions with a variety of coaches in order to rule out the likelihood that the effects were caused by the coach herself. Third, the study could be replicated with students with other diagnoses in which DTT has been found to be an EBP. Fourth, future studies should focus primarily on the coaching within a virtual reality environment in order to rule out the sequence effects of first having the didactic training, as this phase may not be a necessary component to the effectiveness demonstrated by coaching within TLE TeachLivE™.

Fifth, future studies should focus on comparing the effects of using a student confederate for training versus using a student avatar for training. It would be interesting to determine the role that realism and suspension of belief play into the transference of skills from training with an avatar versus training with a student confederate. In other words, does the realism and suspension of belief contribute to the acquisition of skills in a short time period or contribute to the ability of educators to generalize and maintain their newly learned skills to students in their classrooms. Sixth, including student outcomes in this type of research would be beneficial to determine if students acquire skills at a faster rate when their teacher implements an EBP such as DTT with fidelity as compared to lower fidelities of implementation, as previous research suggests (e.g., Koegel et al., 1977). Seventh, a similar study could be conducted utilizing pairs of special educator's in the virtual reality environment. By working in pairs, special educators would serve as a model for one another, similar to the study conducted by Miller and colleagues (1991). Likewise, a similar study could be conducted where special educators are first trained via coaching within TLE TeachLivE™, and then those special educators in turn train their classroom team. The special educator would then provide the coaching themselves to their classroom team either within TLE TeachLivE™ or their current classroom environment. Finally, it would be interesting to determine if the student avatar could 'learn' a novel skill and begin the DTT session with incorrect responses, but as the special educator 'taught' him via error correction and specific praise he would begin to respond correctly. This scenario would enhance the level of intrinsic feedback provided to the user because the number of the avatar's correct responses would increase as the participant provided error correction. In the current study, the researcher had a clear, specific objective where the student avatar would make five correct responses and five incorrect responses during each 10 DTT trial session, in order for the user to have an equal opportunity with error correction and specific verbal praise. However, in the current study once the student avatar was provided with error correction (via a proximity prompt) he would respond correctly. By 'learning' the skill, the student avatar would get the target correct on the next opportunity presented, whereas in the current study he may or may not get it correct. Although, this would cause a decrease in the number of opportunities the user had for error correction as the student avatar 'learned' the skill. In addition, it is not clear whether the student avatar has the ability to 'learn' a skill as it may be too difficult for the interactor to keep track of the skills acquired as compared to non-mastered skills.

**Conclusions**

Six major contributions of this study should be noted. First, this study demonstrated that didactic training simulating a traditional professional development was not sufficient to bring special educators' fidelity of implementation with DTT up to acceptable levels, even when they have received previous DTT training. Second, this study demonstrated that special educators' who have had previous training but were still not implementing DTT with fidelity, were able to be trained to fidelity with less than an hour of coaching and practice in a virtual reality environment, TLE TeachLivE™, following the viewing of a one-hour PowerPoint presentation (i.e., didactic training). Fourth, special educators were able to generalize their newly learned skills from the TLE TeachLivE™ virtual reality environment working with the student avatar to their classrooms working with students with ASD, while maintaining high levels of implementation fidelity. Fourth, coaching and practice within TLE TeachLivE™ following didactic training was not only an effective intervention, but also a socially valid intervention. Fifth, this study demonstrated that after less than two hours of coaching across three to four sessions and practice in a virtual reality environment special educators were able to maintain their fidelity of implementation up to eight weeks after training. Finally, the current study demonstrated the versatility of TLE TeachLivE™ as it was just as effective when used in a physical lab satellite site located a significant distance from the main site where the interactors and technology infrastructure are located.

The findings of the current study are significant as they add to the field of special education teacher preparation by supplementing the evidence of an effective method for training teachers to use EBPs with students with disabilities. The majority of surveyed higher education faculty stated they would consider using computer-simulation in their own classroom, although only 11% had ever used training simulations (Lean et al., 2006). As TLE TeachLivE™ is currently being used in 42 campuses across the country with growing numbers of school districts and international sites adopting the technology (TLE TeachLivE™, 2015), this 11% figure has surely grown in the last nine years. Further, higher education faculty reported that they did not feel using new methods was risky, that their students would react well to computer simulation, and that teaching innovation was a priority at their school (Lean et al., 2006). Therefore, the findings of the current study in conjunction with previous research and the growing number of campuses using virtual reality environments, demonstrate the potential for training educators to implement evidence-based practices via coaching within the virtual reality environment, TLE TeachLivE™.

In order to maximize student achievement, teachers must implement EBPs with fidelity (Vince-Garland et al., 2012; Kretlow & Bartholomew, 2011). Further, effective methods for training teachers must include opportunities for practice without exposing students to less than adequate teaching while allowing educators to generalize their newly acquired skills to students in their own classrooms (Dieker et al., 2008). The current study offers a solution to all of these complexities by providing a modality for practice with an avatar who exhibits ASD-like behavioral characteristics, allowing teachers to practice in an environment similar to their classroom, aiding in skill transferability and retention.

Table 1

*Participant Characteristics.*

| Participant | Age Range (years) | Highest Degree Earned (area) | # Years Teaching (current school) | Teaching Assistant? (# years) | Paraeducator? (# years) | # Years using DTT | Previous DTT Training | State Teaching Certification |
|---|---|---|---|---|---|---|---|---|
| 1 Megan | 30-34 | Master's (special education/ severe & profound disabilities) | 4 (4) | Yes (2) | Yes (1) | 5 | Observation | Severely & Profoundly Disabled |
| 2 Layla | 25-29 | Master's (special education) | 3 (3) | Yes (2) | Yes (2) | 2 | Observation, Peer Modeling | Special Education Elementary/ Middle |
| 3 Pamela | 25-29 | Master's (elementary special education) | 1 (1) | Yes (2) | Yes (2) | 5 | Observation, Peer Modeling, Peer Coaching, In-school Professional Development | Special Education Elementary/ Middle |
| 4 Juliette | 25-29 | Master's (special education/ severe & profound disabilities & applied behavior analysis) | 5 (5) | Yes (.5) | Yes (1) | 2 | Observation, In-school Professional Development | Special Education Elementary/ Middle, Severely & Profoundly Disabled, Elementary Education |
| 5 Kerry | 30-34 | Bachelor's (sports management) | 1 (1) | Yes (1) | Yes (1) | 2 | In-school Professional Development | Severely & Profoundly Disabled |

Table 2

*Mean Interobserver Agreement by Participant and Phase.*

| Participant | Baseline (%) | Didactic Training (%) | Coaching within TLE TeachLivE™ (%) | Maintenance (%) | Average (%) |
|---|---|---|---|---|---|
| 1 Megan | 94.5 | 94.2 | 92.2 | 90.1 | 92.75 |
| 2 Layla | 94.4 | 95.9 | 97.3 | 97.5 | 96.275 |
| 3 Pamela | 85.7 | 88.7 | 88.7 | 94.4 | 89.375 |
| 4 Juliette | 92.4 | 89.9 | 98.6 | 97.3 | 94.55 |
| 5 Kerry | 91.4 | 94.2 | 96.2 | 100 | 95.45 |
| Average | 91.68 | 92.58 | 94.6 | 95.86 | 93.68 |

Table 3

*Participant Classroom Observation Averages and Ranges For Each Phase.*

| Participant | Baseline (%) | Didactic Training (%) | Coaching within TLE TeachLivE™ (%) | Maintenance (%) |
|---|---|---|---|---|
| 1 - Megan | 56 (54-61) | 62.67 (58-66) | 96.67 (96-97) | 95.33 (91-99) |
| 2 - Layla | 63.33 (42-77) | 78.33 (73-87) | 95.67 (87-100) | 100 (100-100) |
| 3 - Pamela | 72.5 (68-80) | 75 (69-82) | 91 (77-100) | 90.33 (86-94) |
| 4 - Juliette | 52.5 (36-69) | 52.33 (48-58) | 94 (92-96) | 97.67 (96-100) |
| 5 - Kerry | 68.17 (48-78) | 66 (59-70) | 93 (89-97) | 97.33 (96-100) |

*Note.* Ranges for each phase appear in parantheses after the average.

Table 4

*Participant DTTISC Scores in the TLE TeachLivE™ Lab.*

| | Session 1 | | Session 2 | | Session 3 | | Session 4 | | |
|---|---|---|---|---|---|---|---|---|---|
| Participant | Trial 1 (%) | Trial 2 (%) | Trial 3 (%) | Trial 4 (%) | Trial 5 (%) | Trial 6 (%) | Trial 7 (%) | Trial 8 (%) | Average (%) |
| 1 - Megan | 95 | 100 | 100 | 100 | 99 | 100 | ----- | ----- | 99 |
| 2 - Layla | 96 | 100 | 100 | 100 | 100 | 100 | ----- | ----- | 99.33 |
| 3 - Pamela | 96 | 97 | 100 | 99 | 100 | 100 | 100 | 99 | 98.88 |
| 4 - Juliette | 81 | 95 | 100 | 100 | 99 | 100 | ----- | ----- | 95.83 |
| 5 - Kerry | 99 | 99 | 100 | 99 | 100 | 99 | ----- | ----- | 99.33 |

*Note.* Participants one, two, four, and five did not require a fourth session in the lab because they scored above the acceptable fidelity of 85% for all classroom observations, therefore no scores are reported.

Table 5

*Percentage of Participants' Ratings on Social Validity Questionnaire.*

| | 1 Strongly Disagree (%) | 2 Disagree (%) | 3 Neutral (%) | 4 Agree (%) | 5 Strongly Agree (%) |
|---|---|---|---|---|---|
| 1. Using evidence-based practices is important when working with students with Autism Spectrum Disorder (ASD). | | | | 20 | 80 |
| 2. Discrete Trial Teaching (DTT) is useful when working with students with ASD. | | | | 60 | 40 |
| 3. The TLE TeachLivE™ lab was a good environment in which to learn DTT Implementation. | | | | 40 | 60 |
| 4. The PowerPoint presentation was helpful in increasing the accuracy with which I implement DTT. | | | 20 | 80 | |
| 5. The individualized coaching was helpful in increasing the accuracy with which I implement DTT. | | | | 20 | 80 |
| 6. Working with Austin, the student avatar, made it easy to transfer what I learned in the lab to working with my own students with ASD in my classroom. | | | | 60 | 40 |
| 7. I plan to continue to use DTT with my students with ASD. | | | | 40 | 60 |

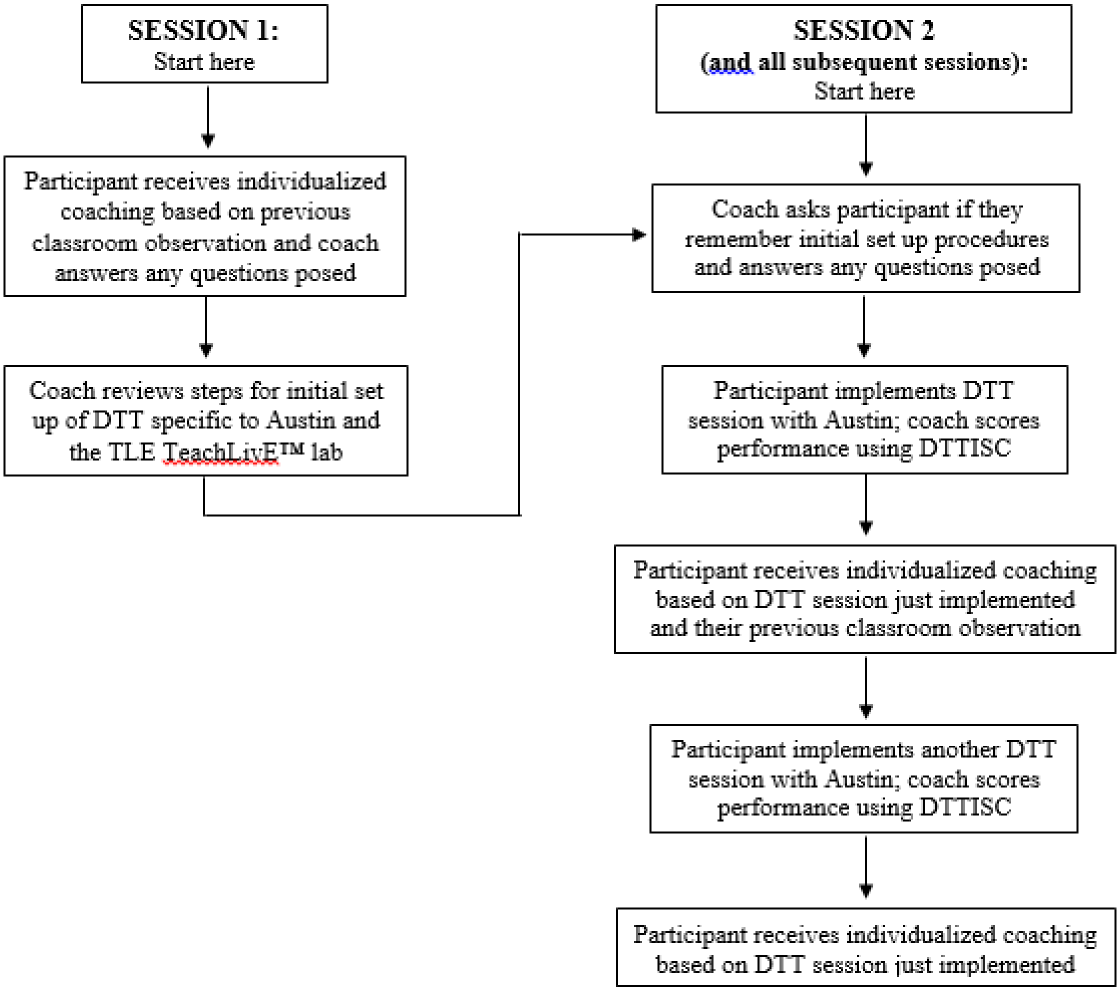


*Figure 1.* Sequence of events per session during Intervention Phase 2: Coaching/ TLE TeachLivE™ lab.

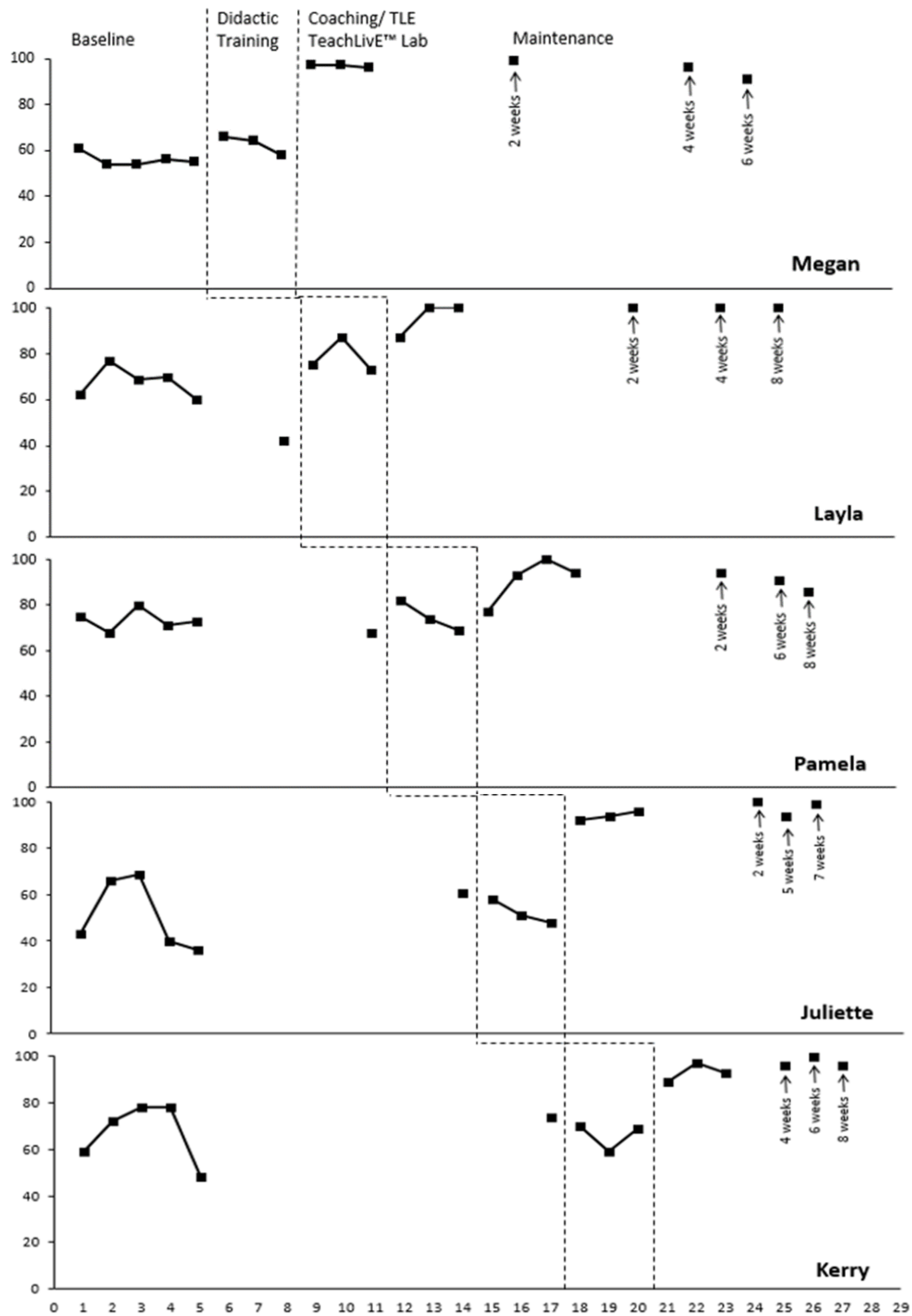


*Figure 2.* Classroom observation data for all participants across all phases.

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Appendix A

Discrete Trial Teaching Implementation Steps Checklist (DTTISC)

**Participant:** ______________________________ **Date:** ______________

**Directions:**
- Record a ✓ if step was implemented correctly.
- Record a -- if step was implemented incorrectly.
- Score all inapplicable steps in the Manage the Consequences components (either steps 8 & 9 OR 10-13) with a X. These steps *are not* calculated in the final score.
- Score all inapplicable steps in the other components with a O (e.g., step 6 if the student is already looking in the teacher's direction). These steps *are* calculated in the final score.

| Component | Completed |
|---|---|
| 1. Get task materials and data sheet ready. | |
| 2. Get reinforcers ready. | |
| 3. Invite student to the table. | |
| 4. Identify reinforcer. | |
| 5. Review activity schedule. | |

**Data Collector:** ______________________

**Phase (circle one):** A B C **Trial #:** ________

**Student:** Austin Other______________

**Program:** ______________ **IOA:** ________

| Components | Trials | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Manage the Antecedents | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 6. Say student's name and wait for them to look in your direction. | | | | | | | | | | |
| 7. Present teaching materials w/ correct instruction ($S^D$). | | | | | | | | | | |
| Manage the Consequences – Correct Response | | | | | | | | | | |
| 8. Provide specific verbal praise. | | | | | | | | | | |
| 9. Provide reinforcer. | | | | | | | | | | |
| Manage the Consequences – Incorrect Response or No Response | | | | | | | | | | |
| 10. Block response by removing materials. | | | | | | | | | | |
| 11. Show neutral expression for 2-3 seconds. | | | | | | | | | | |
| 12. Represent instruction ($S^D$) & materials w/ proximity prompt. | | | | | | | | | | |
| 13. Verbally affirm correct response. | | | | | | | | | | |
| Manage Inter-Trial Interval | | | | | | | | | | |
| 14. Record response. | | | | | | | | | | |
| 15. Provide 3-5 second break at seat. | | | | | | | | | | |
| Number Correct | | | | | | | | | | |
| 16. Indicate finished on activity schedule. | | | | | | | | | | |
| 17. State next activity. | | | | | | | | | | |
| Total number correct (TEACHER steps) | / | | | | | | | | | |
| Percentage correct (TEACHER steps) | % | | | | | | | | | |
| Total number correct (STUDENT answers) | /10 | | | | | | | | | |

Appendix B

Procedural Integrity Checklist for Coaching in the TLE TeachLivE™ Lab

<u>Directions</u>: Mark a ✓ for each component completed and an X for each component not completed.

| Component Video | | | | |
|---|---|---|---|---|
| 1. Provide general positive feedback to participant. | | | | |
| Review scores from DTTISC with participant for each step: | | | | |
| 2. Show participant DTTISC so they can view it during review. | | | | |
| 3. Get task materials and data sheet ready. | | | | |
| 4. Get reinforcers ready. | | | | |
| 5. Invite student to the table. | | | | |
| 6. Identify reinforcer. | | | | |
| 7. Review activity schedule. | | | | |
| 8. Say student's name and wait for them to look in your direction. | | | | |
| 9. Present teaching materials w/ correct instruction ($S^D$). | | | | |
| 10. Provide specific verbal praise. | | | | |
| 11. Provide reinforcer. | | | | |
| 12. Immediately remove materials. | | | | |
| 13. Show neutral expression for 2-3 seconds. | | | | |
| 14. Represent instruction ($S^D$) & materials w/ proximity prompt. | | | | |
| 15. Verbally affirm correct response. | | | | |
| 16. Record response. | | | | |
| 17. Provide 3-5 second break at seat. | | | | |
| 18. Indicate finished on activity schedule. | | | | |
| 19. State next activity. | | | | |
| 20. Review final score with participant. | | | | |
| 21. Provide general positive feedback. | | | | |
| 22. Answer any questions participant has. | | | | |
| 23. Close by telling participant the next step. | | | | |
| Total | /23 | /23 | /23 | /23 |
| Percent | % | % | % | % |

Appendix C

Social Validity Questionnaire

| | 1<br>Strongly Disagree | 2<br>Disagree | 3<br>Neutral | 4<br>Agree | 5<br>Strongly Agree |
|---|---|---|---|---|---|
| 1. Using evidence-based practices is important when working with students with Autism Spectrum Disorder (ASD). | | | | | |
| 2. Discrete Trial Teaching (DTT) is useful when working with students with ASD. | | | | | |
| 3. The TLE TeachLivE™ lab was a good environment in which to learn DTT Implementation. | | | | | |
| 4. The PowerPoint presentation was helpful in increasing the accuracy with which I implement DTT. | | | | | |
| 5. The individualized coaching was helpful in increasing the accuracy with which I implement DTT. | | | | | |
| 6. Working with Austin, the student avatar, made it easy to transfer what I learned in the lab to working with my own students with ASD in my classroom. | | | | | |
| 7. I plan to continue to use DTT with my students with ASD. | | | | | |

Additional comments: ________________________________________________

________________________________________________________________

________________________________________________________________

Appendix D

**CURRICULUM VITAE**

# Dawn W. Fraser

## EDUCATION

*Ed.D.* *Special Education* 2011-2015
Focus: *Teacher Preparation Research*
Dissertation: Using a Virtual Reality Environment to Train Special Educators Working with Students with Autism Spectrum Disorder to Implement Discrete Trial Teaching
Advisors: Dr. Laurie U. deBettencourt & Dr. Tamara J. Marder
Johns Hopkins University, Baltimore, MD

*P.M.C.* *Applied Behavior Analysis (Post-Master's Graduate Certificate)* 2013-2015
Johns Hopkins University, Baltimore, MD

*G.C..* *Education of Students with Autism and Other Pervasive Developmental Disorders (Graduate Certificate)* 2008-2009
Johns Hopkins University, Baltimore, MD

*M.Ed.* *Early Childhood Special Education* 2001-2003
Loyola University Maryland, Baltimore, MD

*B.A.* *Psychology & Early Childhood Education* 1997-2001
University of Maryland Baltimore County, Baltimore, MD

## CERTIFICATIONS

*Maryland Educator Certificate* 2002-2018
Maryland State Department of Education
Certification No. 50-8724
Advanced Professional Certificate
Generic Special Education Infant-3
Early Childhood Education Pre-kindergarten-3
Elementary Education 1-6 and Middle School

*Nonviolent Crisis Intervention* 2000-2002, 2007-present
Crisis Prevention Institution
Practitioner

## PROFESSIONAL EXPERIENCE

*Adjunct Faculty* 2012-present
Department of Special Education
Johns Hopkins University, Baltimore, MD

*Behavioral Intern* 2014-2015
LEAP Autism Program
Kennedy Krieger Institute, Baltimore, MD

*Educational Consultant* 2013-2015
Early Learning Program
Baltimore City Public Schools, Baltimore, MD

*Project Coordinator* 2013-2015
Post-Master's Graduate Certificate in Applied Behavior Analysis Grant
Principal Investigators: Dr. Laurie U. deBettencourt and Dr. Tamara J. Marder
Amount Funded: $170,695
Johns Hopkins University, Baltimore, MD

*Project Coordinator* 2012-2015
Autism Hybrid Graduate Certificate Program Grant
Principal Investigator: Dr. Tamara J. Marder
Amount Funded: $124,575
Johns Hopkins University, Baltimore, MD

*Doctoral Fellow* 2011-2015
Department of Special Education, OSEP Leadership Grant
Johns Hopkins University, Baltimore, MD

*Migrant Teacher* 2011
Summer Migrant Program, 3-year old classroom
Queen Anne's County Public Schools, Sudlersville, MD

*Program Developer and Special Educator* 2007-2011
Regional Autism Program, 2nd-5th grade
Bayside Elementary School
Queen Anne's County Public Schools, Stevensville, MD

*Special Educator* 2007-2010
Extended School Year, K-8th grade
Queen Anne's County Public Schools, Stevensville, MD

*Family Trainer* 2007-2009
Autism Waiver Services
The Whole Self Center, Annapolis, MD

*Special Educator* 2006-2007
Co-teaching and Resource Settings, 2nd grade
Centreville Elementary School
Queen Anne's County Public Schools, Centreville, MD

*Special Educator* 2002-2006
Co-teaching and Resource Settings, PreK-5th grade
Fort Smallwood Elementary School
Anne Arundel County Public Schools, Pasadena, MD

*Academic Tutor* 2003-2011
In-home services for K-5th graders
Queen Anne's and Anne Arundel Counties, MD

*Special Educator* 2006-2007
Infants and Toddlers Program - Home-based Services, Therapy Groups
Anne Arundel County Public Schools, Glen Burnie, MD

*Program Aide* 2001-2002
LEAP Program, 7-11 year olds
Kennedy Krieger Institute, Baltimore, MD

*Clinical Assistant* 2000-2001
Neurobehavioral Unit
Kennedy Krieger Institute, Baltimore, MD

## RESEARCH INTERESTS

Special Education Teacher Preparation
Evidence-based Practices in Special Education and Implementation Fidelity
Family Partnerships
Autism Spectrum Disorder
Applied Behavior Analysis including Data-based Decision Making

## PUBLICATIONS

**Fraser, D. W.** (2013). Five tips for creating independent activities aligned with the common core state standards. *Teaching Exceptional Children, 45*(6), 6-15. doi:10.1177/004005991304500601

Marder, T. J., & **Fraser, D. W.** (2012). Evidence-based practice for special educators teaching students with autism. *New Horizons for Learning Special Education Journal, 10*(2). Retrieved from http://education.jhu.edu/PD/newhorizons/Journals/specialedjournal/MarderandFraser

## PRESENTATIONS

Hooks, S. D., **Fraser, D. W.**, & Nagro, S. A. (2015, April). *Strategies to meet the needs of non-responders.* Poster presentation at the annual meeting of the Council for Exceptional Children, San Diego, CA.

Hooks, S. D., **Fraser, D. W.**, & Nagro, S. A. (2015, April). *University-school partnerships, schoolwide PD, inclusive classrooms, and student engagement strategies*. Poster presentation at the annual meeting of the Council for Exceptional Children, San Diego, CA.

Hooks, S. D., **Fraser, D. W.**, & Nagro, S. A. (2014, November). *A decade of practice: Are special educators using research-based tertiary interventions?* Presentation at the annual meeting of the Teacher Education Division, Council for Exceptional Children, Indianapolis, IN.

Marder, T. J., deBettencourt, L. U., & **Fraser, D. W.** (2014, November). *Overview of the post master's certificate in ABA at Johns Hopkins University School of Education.* Presentation at the annual meeting of the Teacher Education Division, Council for Exceptional Children, Indianapolis, IN.

True, J. M., Nagro, S. A., Hooks, S. D., Larson, K., & **Fraser, D. W.** (2014, November). *Does instructor-pair collaboration improve special education teacher preparation?* Presentation at the annual meeting of the Teacher Education Division, Council for Exceptional Children, Indianapolis, IN.

**Fraser, D. W.**, & Marder, T. J. (2014, November). *Using evidence-based practices to teach students with Autism Spectrum Disorders.* Facilitated discussion at OCALICON, Columbus, OH.

Nagro, S. A., Hooks, S. D., & **Fraser, D. W.** (2014, May). *Proactive teacher strategies to promote student engagement and learning for hard to reach students in inclusive settings.* Presentation at the Pacific Rim International Conference on Disability and Diversity, Honolulu, HI.

**Fraser, D. W.** (2014, April). *Post-secondary engagement of nonpublic special education facilities graduates with autism spectrum disorders.* Poster presentation at the annual meeting of the Council for Exceptional Children, Philadelphia, PA.

**Fraser, D. W.**, & Marder, T. J. (2014, January). *Using a hybrid model to prepare educators to teach students identified with autism spectrum disorders*. Presentation at the International Conference on Autism, Intellectual Disability, and Developmental Disabilities, Division on Autism and Developmental Disabilities, Council for Exceptional Children, Clearwater Beach, FL.

**Fraser, D. W.**, deBettencourt, L. U., & Marder, T. J. (2013, November). *Using a hybrid model to prepare special educators to teach students with autism spectrum disorder*. Presentation at the annual meeting of the Teacher Education Division, Council for Exceptional Children, Fort Lauderdale, FL.

**Fraser, D. W.** (2013, November). *Case analysis of special education teacher preparation programs for students with autism spectrum disorders*. Poster presentation at the annual meeting of the Teacher Education Division, Council for Exceptional Children, Fort Lauderdale, FL.

Nagro, S. A., Hooks, S. D., & **Fraser, D. W.** (2013, November). *Using teacher input and research-based training techniques to target proactive teaching strategies*. Presentation at the annual meeting of the Teacher Education Division, Council for Exceptional Children, Fort Lauderdale, FL.

**Fraser, D. W.**, & Marder, T. J. (2013, November). *Johns Hopkins University School of Education's post master's certificate in applied behavior analysis*. Poster presentation at the annual meeting of the Maryland Association for Behavior Analysis, Baltimore, MD.

**Fraser, D. W.** (2013, April). *Post-secondary outcomes for nonpublic special education facilities graduates with autism spectrum disorders*. Poster presentation at the annual meeting of the Council for Exceptional Children, San Antonio, TX.

## **PROFESSIONAL DEVELOPMENT SESSIONS** (*invited)

***Fraser, D. W.** (2014, October). *Effective strategies for problem behaviors*. Presentation to the Kent County Special Education Citizens Advisory Council, Chestertown, MD.

*Marder, T. J., & **Fraser, D. W.** (2014, May). *Autism: Effective strategies for problem behaviors.* Presentation at the Montgomery County Public Schools Special Education Summit, Rockville, MD.

***Fraser, D. W.** (2013, October). *Student success: Promoting independence and engagement for learning, session 2: Addressing student work habits*. Professional development series provided to Baltimore City Public Schools early childhood special education teachers, Baltimore, MD.

***Fraser, D. W.** (2013, August). *Student success: Promoting independence and engagement for learning, session 1: Classroom structure*. Professional development series provided to Baltimore City Public Schools early childhood special education teachers, Baltimore, MD.

***Fraser, D. W.**, Hooks, S. D., & Nagro, S. A. (2013, May). *Proactive teacher strategies to promote student engagement and learning: Session 1*. Professional development series provided to Henderson Hopkins Elementary and Middle School, Baltimore, MD.

***Fraser, D. W.**, Hooks, S. D., & Nagro, S. A. (2013, April). *Proactive teacher strategies to promote student engagement and learning: Session 2*. Professional development series provided to Henderson Hopkins Elementary and Middle School, Baltimore, MD.

***Fraser, D. W.** (2010, February). *Teaching students with autism spectrum disorder*. Professional development provided to Kennard Elementary School, Centreville, MD.

## UNIVERSITY TEACHING

**Graduate Level Courses Taught**

*Johns Hopkins University*

Classroom Programming for Students with Autism (hybrid)
Educational Alternatives for Students with Special Needs (face-to-face)
Characteristics of Students with Mild to Moderate Disabilities: Learning Disabilities, Emotional Disturbance, and Mild Intellectual Disabilities (hybrid)
Survey of Autism and Other Pervasive Development Disorders (hybrid)
Induction Internship in Severe Disabilities (face-to-face)
Culmination Internship in Severe Disabilities (face-to-face)
Teaching Communication and Social Skills (face-to-face)

**Guest Lectures for Graduate Level Courses**

*Johns Hopkins University*

Introduction to Children and Youth with Exceptionalities (face-to-face)
Current Trends and Issues in Early Childhood Special Education (face-to-face)

**Teaching Assistant for Graduate Level Courses**

*Johns Hopkins University*

Classroom Programming for Students with Autism (face-to-face)
Induction Internship in Severe Disabilities (face-to-face)
Culmination Internship in Severe Disabilities (face-to-face)

## UNIVERSITY SUPERVISION

**Graduate Level University Supervision**

*Johns Hopkins University*

Internship in Severe Disabilities: Induction (face-to-face)
Internship in Severe Disabilities: Culmination (face-to-face)
Mild to Moderate Disabilities Internship: Induction-Elementary/Middle (face-to-face)
Mild to Moderate Disabilities Internship: Culmination-Elementary/Middle (face-to-face)

## PROFESSIONAL SERVICE

**National**

*Guest Reviewer*

Focus on Autism and Other Developmental Disabilities 2014-present
Young Exceptional Children 2014-present

*Evidence-Based Practices Reviewer*

National Professional Development Center on Autism Spectrum Disorders 2012
Frank Porter Graham Child Development Center, University of North Carolina Chapel Hill

*Proposal Reviewer*
American Educational Research Association Annual Meeting 2014
Teacher Education Division of the Council for Exceptional Children Annual Conference 2012-present
Council for Exceptional Children Annual Convention 2012-present

*Student Representative*
Small Special Education Programs Caucus, Teacher Education Division, Council for Exceptional Children 2014-2015

*Student Editorial Board*
Young Exceptional Children 2011- 2013

*Student Reviewer*
Teacher Education and Special Education 2011- 2015

**State and Local**
*Queen Anne's County Public Schools* 2006-2011
School-based Assistive Technology Coordinator
Maryland Council of Teachers of Mathematics
Child Study Team
Faculty Advisory
Science Committee
Partnering for Youth after School Program

*Anne Arundel County Public Schools* 2002-2006
Educational Management Team Chair
School Improvement Team
Math Committee

## AWARDS

*Student Excellence in Special Education* 2015
Johns Hopkins University School of Education

*Leadership in Special Education Fellowship* 2011-2015
U.S. Department of Education Office of Special Education Programs

*Education of Students with Autism Fellowship* 2008-2009
Maryland State Department of Education

*Recognition of Excellence Award* 2007
Praxis II Elementary Education: Content Knowledge

*Summa Cum Laude* 2003
Loyola University

*Cum Laude* 2001
University of Maryland Baltimore County

**PROFESSIONAL MEMBERSHIPS**

*Association for Behavior Analysis International* 2015

*American Association of Colleges for Teacher Education* 2015
Research & Practical Expertise Special Interest Group

*Association of Professional Behavior Analysts* 2014-present

*Maryland Association for Behavior Analysis* 2014-present

*American Education Research Association* 2014-present
Division of Teaching and Teacher Education
Division for Educational Policy and Politics
Special Education Research Special Interest Group
Educational Change Special Interest Group

*Council for Exceptional Children* 2011-present
Division of Early Childhood
Division of Autism and Developmental Disabilities
Council for Children with Behavioral Disorders
Teacher Education Division
    Early Career Special Interest Group
Technology and Media Division
Maryland Council for Exceptional Children