Handbook of Research on Human Development in the Digital Age

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A volume in the Advances in Human and Social Aspects of Technology (AHSAT) Book Series

Published in the United States of America by
IGI Global
Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA, USA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com

Library of Congress Cataloging-in-Publication Data

Names: Bryan, Valerie C., editor. | Musgrove, Ann T., 1956- editor. | Powers, Jillian R., 1972- editor.
Title: Handbook of research on human development in the digital age / Valerie C. Bryan, Ann T. Musgrove, and Jillian R. Powers, editors.
Description: Hershey : Information Science Reference, [2017]
Identifiers: LCCN 2017010367| ISBN 9781522528388 (hardcover) | ISBN 9781522528395 (ebook)
Subjects: LCSH: Computer-assisted instruction--Psychological aspects. | Educational psychology. | Developmental psychology.
Classification: LCC LB1028.5 .H3164 2017 | DDC 371.33/4019--dc23 LC record available at https://lccn.loc.gov/2017010367

This book is published in the IGI Global book series Advances in Human and Social Aspects of Technology (AHSAT) (ISSN: 2328-1316; eISSN: 2328-1324)

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

Chapter 15
Applied Behavior Analysis as a Teaching Technology

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ABSTRACT

Applied behavior analysis is known as an effective way to address the needs of people with autism spectrum disorders. The layperson may also associate behavior analysis with forensic psychology through their experience of crime dramas such as Criminal Minds: Behavior Analysis Unit. However accurate or simplified these portrayals they are a very narrow view of the larger field of behavioral science. Behavior analysis has a host of applications in the real world. Some of these applications include but are certainly not limited to the determination of social policies, advertising, policing, animal training, business practices, diet and exercise regimens and education. In this chapter the authors will focus on how applied behavior analysis can be used as a teaching technology from the behavioral and educational literature that has the potential to help lead the way out of the educational crisis faced in the United States of America and abroad.

INTRODUCTION

Applied behavior analysis (ABA) is a science traditionally tied to solving practical problems based on the discoveries from the basic science of behavior. It is the application of behavioral principles to change socially significant behavior to a meaningful degree through careful observations and systematic experimentation (Baer, Wolf, & Risley, 1968). Webster's Dictionary (n. d.) defines technology as the

DOI: 10.4018/978-1-5225-2838-8.ch015

use of scientific knowledge to solve a practical problem. One of the defining characteristics of ABA as "technological" is that its effects are replicable and available to others via precise descriptions of procedural operations (Baer et al., 1968). Thus, not only any instruments, apparatus, or techniques, but also strategic methodological processes developed within the behavior analytic tradition, are included in the definition of technology (Layng & Twyman, 2013) herein described in this chapter. Simply, ABA is a technology which is used to change behavior.

Lattal (2008) further distinguished technologies developed within the behavior analytic discipline as endogenous technology (e.g., the operant chamber) while those developed outside of this discipline as exogenous technology (e.g., the iPad™). Assimilating or merging exogenous technology with endogenous technology can produce powerful effects on evaluation in our society, particularly when applied to our education system (Escobar & Twyman, 2014).

Endogenous technology can be defined as the applications of discoveries from the laboratory to solve student learning problems in the classroom via systematically sequenced educational outcomes with frequent measures to mastery, learner-centered active responding opportunities, and individualized pacing toward the ultimate goals. Pedagogy has always been an integral part of the research tradition of behavior analysis (Keller, 1968; Lindsley, 1991; Skinner, 1968). Despite the existence of empirically validated pedagogical practices shown effective in facilitating student learning, advances of exogenous technology applied in the classroom seem to remain independent of and ignorant of endogenous technology.

For example, in a review of evidence-based online instructional strategies, it was reported that online instructions involving multi-media did not produce superior effects in student performance (Means, Toyama, Murphy, Bakia, & Jones, 2010). Such results were not surprising, as those studies compared lectures delivered via either in-person or video formats. Both instructional methods were literally identical and consisted of passive learning without active student responding. Advanced exogenous technology alone, without integrating endogenous technology as the foundation, yielded no significant educational outcomes. ABA offers many benefits if implemented in the classroom. These include ways to teach, ways to organize teaching materials and objectives, and ways to think about schooling in general.

Unfortunately, adapting exogenous technology without endogenous technology in the education system is common. In its 2016 National Education Technology Plan, the Office of Educational Technology defines technology as those tools that a classroom has for learning such as: laptops, computers, iPads™, and phones (US Department of Education, 2016). This definition does not fully account for the essential learning process necessary for successful educational outcomes and ignores the role of teachers who serve as scientists to apply scientific knowledge to solve practical learning problems. Such a prevailing notion has contributed to an ongoing culture that dismisses teachers as valued and technological, which has become a barrier when discussing practical solutions to a serious problem. As a result, ABA is not being consistently used in schools and this may pose a problem.

Recent test results still show that children in the United States are performing in school below average when compared to other children in the world (Carnoy & Rothstein, 2013). The need to improve our education system is imperative; even though we have spent money and time to do so, we have yet to be competitive on the world stage. Science and digital technology have given us access to a great number of wonderful tools, but without a science of teaching we cannot effectively use these tools to improve the learning of our children. The process or the way we teach is an area of opportunity for change.

Hundreds of effective pedagogical tactics and strategies have been identified as evidence-based procedures in the behavioral literature (See Greer, 2002, Chapters 5 and 6 for a list of over 200 such tactics). These tactics and strategies constitute a technology of teaching and as such should be included in our consideration of advancements in the digital age. We have seen inclusion of some of these strategies in special education where there has been wide spread adoption of tools like functional behavior assessment and positive behavior supports. Nearly 7,000 schools in over 37 states in the United States have adopted School Wide Positive Behavior Supports (SWPBS) in conjunction with Response to Intervention (RTI) to increase prosocial and academic behaviors while decreasing incidence of conduct referrals, seclusion, restraints, suspensions and juvenile incarceration of school-aged children ("What is School-Wide Positive Behavior Support?" 2009). These tools are endogenous technology but on a whole due to the precision and depth of understanding required to implement such technologies and the system of schooling they will require their own treatment outside the scope of this chapter.

Lastly, academic teaching strategies such as scaffolding instruction, use of Direct Instruction, using scripted curriculum for core subjects of math, reading and social studies, along with progress monitoring of academic interventions, are all based on fundamental principles of behavior. As such a science of teaching benefits learners at all ability levels (e.g., general education, gifted and talented, and students with learning differences) and represents, additionally, an opportunity to offer greater equity (fiscal and human resources) across the board for all, regardless of race, gender or socioeconomic status (SES). In this way we can fulfill the mandate of President Barack Obama of the United States through Exec. Order No. 13707, 3 C.F.R. 56365 (2015) to use behavioral science to improve lives and to improve the access to educational opportunities for all. Our focus in this chapter will be on the use of ABA as a technology for teaching.

BACKGROUND

Why ABA as a Teaching Technology?

ABA has a number of strengths when considered as a technology of teaching. Teachers who are strategic scientists of instruction learn to know immediately when to change what they are doing in the classroom because they are constantly measuring learning and they are providing intensive learning opportunities for their students. With the knowledge of the science of teaching, they understand how to arrange the learning environment in such a way as to optimize the students' learning.

According to Cooper, Heron and Heward (2007), ABA has six important elements that make it what it is: effective, accountable, public, doable, empowering, and optimistic. ABA is effective because it produces practical results for teachers and for the students they are teaching. ABA is accountable because it allows us to learn from our mistakes and we can try something else if it doesn't work. ABA is public because there is no hidden "magic or miraculous event."

This public aspect allows others to replicate what we do. This is an important aspect because we want to support effective teaching across the field of education. ABA is doable because it is simply the things that we already know how to do like: repetition, consistency, reinforcement, and so on. We just use a scientific terminology and a scientific practice to move what we "know" how to do from the common understanding and into a scientific technology. ABA is empowering because it is about practical tools that can be learned by practitioners and gives them confidence in their skills. ABA is optimistic because it is a science that assumes that all people have the ability to change for the better and to make the world a better place.

One of the earliest examples of ABA as a teaching technology is that of Skinner's teaching machines. In 1954, Skinner designed machines that students could use to learn new information. The machines incorporated two important elements of ABA as a teaching technology. Firstly, they allowed for each student to learn individually, at their own pace. Secondly, they provided immediate feedback to the learner, telling the learner whether they had responded correctly or incorrectly (Hill, 1977).

Another example of using ABA in education with a bit more modern twist is that of using Programmed Instruction (an ABA tactic) to teach students how to write a simple Java™ computer program. This computer-based programmed instruction tutoring system was used with lectures and collaborative learning experiences to successfully teach students to write their own computer programs (Emurian, Hu, Wang, & Durham, 2000). This type of learning lends itself particularly well to this teaching strategy and highlights the importance of teachers learning how to match the teaching technology to the teaching task or goal.

Direct and continuous measurement in ABA allows the detection of small improvements that may otherwise be overlooked. The more you use ABA with positive outcomes the more optimistic your outlook on your work and on your effectiveness as a teacher, creating positive supports for people who are often stressed and feeling overwhelmed and overworked. ABA is an evidence-based practice and a field where peer-reviewed literature such as journals and books give many examples of successful practice that has been replicated over decades in many subjects.

Lastly, ABA is not only an effective teaching technology, it also meets all of the requirements of a *Response to Intervention* (RTI) tiered approach to remediating learning and behavioral problems required by the "No Child Left Behind Act of 2001" (VanDerHeyden, Witt, & Gilbertson, 2007). RTI requires screening for learning and behavioral problems (e.g., curriculum based or other academic and functional behavior assessments), ongoing progress monitoring (e.g., ongoing data collection and analysis), data based decision making (e.g., decision analysis protocol of changes to instructional strategies post visual inspection of student data and verbally-mediated behaviors), and a multi-level prevention system (e.g., ongoing implementation of evidence-based procedures, teaching and expanding of student's communities of reinforcers). There are specific characteristics of teaching as applied behavior analysis as shown in Table 1 and which qualify ABA as an approved RTI approach.

Table 1. Characteristics of teaching as applied behavior analysis (adapted from Greer, Keohane, & Healy, 2002, p. 121)

Screening for learning and behavioral problems: Teachers continuously measure teaching and student responses. Teaching is driven by the moment-to-moment responses of each individual student and existing research findings. All instruction is individualized whether the instruction is provided in a one-to-one setting or in groups.
Ongoing progress monitoring: Graphs of the measures of student's performance are used for decisions about which scientifically-tested tactics are best for students at any given instructional decision point.
Data-based decision making: Expertise in the science is used to make moment-to- moment decisions based on the continuous collection of data, its visual summary in graphs, and the precision of the vocabulary of the science used with the data. Indeed, the data language is part of that science. The precision of the vocabulary of the science drives the production of good outcomes. The progress of students is always available for view in the form of up-to-date graphs that summarize all of the students' responses to instruction.
Multi-level prevention system: Logically and empirically tested curricula and curricular sequences are used that are repertoires of behavior. The goals of instruction (antecedents, responses, and consequent contingencies within setting events) are educationally and socially significant repertoires. The principles of the basic science of the behavior of the individual and the 200+ tactics from the research are used to teach educationally and socially significant repertoires. Tactics must be fitted to the individual needs of students. Teachers/practitioners are strategic scientists of pedagogy/therapy and applied behavior analysis because the process of determining what each student needs at any given point requires a strategic scientific analysis.

Educational Technologies Derived from Applied Behavior Analysis

The appendix to this chapter describes the Applied Behavioral Analysis in detail including case studies and practical examples. The theoretical, experimental and applied branches of behavior analysis all converge to establish a multitude of avenues from which new behaviors can be taught, learned behaviors can be maintained, and socially undesirable behaviors can be reduced. Our focus in this chapter is to describe how this convergence of science and education has led to the development of over 200 tactics and strategies that make up a technology of teaching. In the next section and throughout the chapter, we will describe some of these technologies and how some models of schooling are training teachers to be effective users of the technology available to them. The following are some of the methods derived from ABA used to teach these objectives.

Discrete Trial Training

Discrete trial training (DTT) refers to delivery of discrete trials which are instructional units. Each unit is a potential operant targeted to teach. Within DTT, tasks are broken down into smaller parts. There are four main components of DTT: (a) present an antecedent with a child's motivation and attention in place (e.g., the student is looking at the teacher and the teacher points to a map and delivers an instructional command, "What is the capital city of New York State?"), (b) wait up to three seconds for the child's response, (c) the child's response (e.g. The student says, "Albany" or "Manhattan"), and (d) deliver a consequence for the response (e.g. reinforcement for a correct response or a correction for an incorrect response (e.g, The teacher says, "Yes, it is Albany" or in the second instance, "The capital city is Albany.") (Smith, 2001; Sarokoff & Sturmey, 2004).

Another example of DTT is as follows: 1. A teacher gains student attention (e.g., eye contact), 2. A teacher presents an instructional command, "do this" while simultaneously modeling hands clapping, 3. the child imitates the teacher's clapping correctly within three seconds, 4. the teacher provides reinforcement in the form of verbal praise for the correct response. The delivery of a discrete trial ends when the teacher records "+" on the data sheet. In this scenario, a three-term contingency is delivered and thus operant conditioning is conducted through DTT. Skills in academic, social, communication, self-help and play skills can all be taught using DTT.

Direct Instruction

Direct Instruction (DI) (Engelmann & Carnine, 1982) is one of the most well-known and researched forms of scripted programmed instruction. DI has been researched in over 150 studies comparing it to other such teaching methods. Results of Adams & Engelman's (1996) meta-analysis showed that DI is more effective than other methods in 64% of those studies. With DI the teaching procedures include: student responses to instructional objectives, opportunities for teacher guided performance and finally independent demonstration and performance of skills taught.

Direct instruction (DI) refers to an explicit teaching of a skill-set and relies on a systematic curriculum that are delivered through a prescribed behavioral script. DI is teacher-centered and focuses on clear behavioural and cognitive objectives.

The theoretical basis of DI is operant conditioning models developed by Skinner. Engelmann and Carnine (1982) identified three major categories of cognitive knowledge which are presented in order from simple to complex: Basic forms, joining forms, and complex forms. Classifying knowledge forms provides teachers with a basis for designing instructional sequences that can be used repeatedly with similar forms of knowledge.

For example, teachers can arrange an instructional sequence starting by teaching basic discriminations, then related discriminations, teaching rules and then teaching cognitive operations (Kenny, 1980). Core features of DI include using scripts that permit the use of pretested examples and sequences. A response signal is an integral part of the scripts which enable teachers to pace their instruction at a high rate.

DI in a small group with the features mentioned above enable teachers to provide repetitious practice with students acting as models for each other. *Choral responding* in a high rate, immediate corrective feedback, and differential praise are other core features of direct instruction strategies (Binder & Watkins, 1990). DI is used in resource rooms in special education programs as well as the general classroom setting to teach all core subject: math, reading, spelling, social studies, science and English Language Learners. They are not only an effective approach for academic remediation for children at risk, but provide opportunities for movement from one group to another for students who are paced faster through the curriculum (i.e., advanced learners).

Precision Teaching

Precision teaching (PT) is a precise and systematic method of evaluating instructional tactics and curricula. It emphasizes rate of responding and the standardization of visual displays. Counts per minutes are used to evaluate the student's mastery and fluency with tool or component skills of more complex repertoires (Greer, 2002). By focusing on fluency, teachers can adjust the curricula for each learner to maximize the learning based on the learner's personal fluency measurements (Lindsley, 1990; Lindsley, 1991).

PT has been utilized for teaching a variety of behaviors such as handwriting, mathematics, vocational skills and recreational skills with a variety of populations including typically developing individuals and persons with emotional disorders or developmental disorders (Ramey, Lydon, Healy, McCoy, Holloway, & Mulhern, 2016). With Precision Teaching (PT) (Pennypacker, Gutierrez, & Lindsley, 2003; White & Harring, 1976) the skills learned through DI are then practiced. Practice occurs typically in pairs, self-timed, until students can perform within a specified criterion for number and rate of responses (i.e. how many and how fast). Students then plot their own data on Standard Celeration Charts and follow or monitor their own progress until a fluency criterion is achieved for mastered skills. The expectation for learning and demonstrating skills is marked on the graph. The nature of this type of instruction mixes DI, PT as well as Personalized System of Instruction (PSI) discussed in the next section.

Through this process students learn to become sufficient at self-monitoring and self-management. Additionally, they learn to work cooperatively with others (e.g. peer-tutoring) and gain important organizational skills by using fluency methods such as SAFMEDS (Say all fast, minute each day, shuffled) (Eschelman, 2004). Group contingencies are implemented to assign points and provide reinforcement to the group based on individual student academic performance. These types of methods build motivation into the process of learning.

Personalized System of Instruction

Personalized System of Instruction (PSI), developed by Fred S. Keller in 1968, is a behavioral system of instruction. In PSI, each study unit is divided into subunits and objectives and students move through instructional material at their own pace. Students must meet preset criteria for each unit. Information of instruction is transmitted in written form between teachers and students. Proctors or tutors provide individualized instruction when needed. (Greer, 2002; Sherman, Raskin, & Semb, 1982)

Class Wide Peer Tutoring

Class Wide Peer Tutoring (CWPT) is a form of peer-mediated instruction where pairs of students alternately play roles of tutor and tutee. The tutors ask questions, mark whether tutees' responses are correct or incorrect, and provide feedback. Teachers supervise tutoring and reinforce good tutoring. CWPT has been used for learning spelling, math facts, reading, vocabulary, and facts related to a subject area. CWPT benefits both of the tutors and tutees in learning academic and social skill by providing them more opportunities to practice those skills, encouraging them to engage in active learning (Greenwood, Delaquadri, & Hall, 1989; Kamps, Barbetta, Leonard, & Delaquadri, 1994).

Stimulus Equivalence and Relational Frame Theory

Stimulus Equivalence (SE) and Relational Frame Theory (RFT) explain sources of "derived" or "emergent" human verbal behavior which don't have direct reinforcement history within stimulus-response relations for an individual (Barnes-Holmes, Barnes-Holmes, Smeets, Cullinan, & Leader, 2004).

SE is an empirical phenomenon which was first explained by Murray Sidman. SE provides a logical basis for explaining "derived" or "emergent" stimulus-response relations exhibited in human verbal behavior. Sidman (1982) conceptualized SE in terms of the mathematical relations of reflexivity, symmetry, and transitivity. Reflexivity of a stimulus relation can be demonstrated when each stimulus bears the relation to itself ("if A then A"). Symmetry requires reversibility between stimuli A and B ("if A then B", "if B then A"). To determine whether stimulus relation is transitive, it requires a third stimulus, C. Once "if A, then B" and "if B, then C" have been established, transitivity requires "if A, then C" to emerge without differential reinforcement. If an individual learns the relations "if A, then B" and "if A, then C" through differential reinforcement, "if B, then C" relation emerges with direct reinforcement history (Sidman & Tailby, 1982).

RFT provides a basis to explain other derived stimulus relations (e.g., mutual entailment, combinatorial entailment, transformation of stimulus functions) and are more general than the terms in SE (e.g., reflexivity, symmetry, and transitivity). Sidman's (1982) SE explains equivalence relations but this does not work for other relations (e.g., bigger than, before-after, opposite, etc.). In RFT, stimulus functions can be changed based on the derived relations. Research demonstrated that stimulus functions can transfer between members of an equivalence class and these functions will be changed.

Exogenous Technologies Used to Enhance the Practice of Applied Behavior Analysis

Although Applied Behavior Analysis itself has been discussed in this chapter as a scientific "technology" of teaching there are also many other applications of what the mainstream refer to as technology (i.e. exogenous technology) used throughout the greater field of applied behavior analysis. In this section technology that is not a part of the science of teaching (such as evidence-based teaching strategies and resultant curriculum) will be referred to as exogenous technology. The use of exogenous technology is not new to the field of Applied Behavior Analysis. From the advent of the teaching machine by B.F. Skinner (Hill, 1977); that takes students through a learning module frame by frame allowing advancement to the next step only after first mastering the previous step, to the use of Microsoft Excel programs to input and graph data for the purpose of visual analysis (Alberto & Troutman, 2012) this chapter will discuss some of those technologies and how they have been applied in the field. Exogenous technology has allowed for multiple advancements in both the dissemination and application of behavior analytic procedures in education, home, and other institutions around the world. In this section we will focus on the use of exogenous technologies to educational applications as they relate to students of applied behavior analysis, practitioners of applied behavior analysis, and students in educational settings with learning differences.

Examples of Exogenous Technologies Used to Increase Communication Skills

Picture Exchange Communication Systems (PECS) (http://www.pecsusa.com/research.php) is a form of communication training that uses picture icons from single pictures, to strings of pictures to text of words in a sentence strip to allow individuals with no communication skills to develop first instances of non-vocal communication while gradually shaping up vocal communication skills in children with autism spectrum disorder and other communication disorders. The advent of more Hi-tech applications include but are not limited to the use of text to speech functions in different text programs across platforms like Mic vocal output devices such as Sound Buttons, the Dynavox (http://www.dynavoxtech.com/products) to digital applications that can be used on ever smaller devices like an iPad or Smartphone like Proloquo2Go (http://www.assistiveware.com/product/proloquo2go) which uses similar principles of communication training as PECS. In Proloquo2Go the difference is that the picture icons and text are programmed with different choices of vocal output: from male to female and adult to children's voices, allowing for individuals with limited to no vocal capacity for speech to communicate through vocal output sources.

Examples of Exogenous Technologies Used to Increase the Dissemination of Applied Behavior Analysis

Correspondence and distance learning has long been a method for learning new skills and enhancing one's practice. In the 21st Century we have seen universities all over the world develop on-line: certificate, master's, and doctoral level programs, that can all be accessed from a computer without ever having to step foot into a classroom. Additionally, with the advent of Skype's visual conference calling and other communication platforms it has become ever easier to connect practitioners and teachers of Applied Behavior Analysis to people in more remote locations with limited access to trained professionals. On-line educational programs in conjunction with digital conferencing platforms have allowed for trained professionals to provide a level of education, training, and supervision of practitioners to a degree not seen in any previous time in history. These exogenous technologies have allowed for the further development of skills and increased dissemination of ABA around the world. Exogenous technology is not without limitations. One limitation of the growing propensity for distance learning and distance supervision models using such technologies is the limited in-person contact with trained professionals. This may lead to an inability to closely monitor students of applied behavior analysis who participate in distance practicums and receive distance supervision in the same ways that you could in person or when in the same local professional community.

Many on-line instructional practices used have not led to greater student performance (Means, Toyama, Murphy, Bakia, & Jones, 2010). These types of concerns have led the credentialing body for Behavior Analysts, The Behavior Analyst Certification Board (BACB) (http://bacb.com) to create strict regulations around the amount and extent to which distance supervision can occur within the required hours for certification. This was done while establishing quality indicators and requirements for BACB Supervisors to ensure the quality of supervised experiences for practitioners. Finally, restrictions to the number of hours of supervision that can be done remotely was enacted to ensure the majority of training and supervision be hands-on practical experiences.

The positive aspect of this use of exogenous technology has been the greater dissemination of information to parents, teachers, and social service personnel who live and work in remote areas with little to no contact with licensed and/or credentialed professionals. This has led to the increase in awareness of applied behavior analysis as well as the increased development of instructional and training programs around the world in consultation with qualified professionals.

Examples of Exogenous Technologies Used to Enhance the Practice of Applied Behavior Analysis

The practice of applied behavior analysis requires great attention to detail. It requires that often, large amounts of data be collected, graphed and visually analyzed, and used to make timely instructional decisions to increase student attainment of specified goals. More and more educators are using exogenous technologies to engage in these types of practices. For example if you were to input ABA or data collection into Google Play for Android and/or iTunes store for Mac platforms you will now find a multitude of such applications. Practitioners are using such exogenous technologies to assist in the timely tracking of data as well as graphing. Advanced technology companies such as TNAC (Technology North Active Care) are enriching such technologies with the use of behavior analytic consultants to not only allow for data collection and the generation of visual displays of data via graphs but also to incorporate the use of evidence-based data analytic rules as published in the field (Keohane & Greer, 2005) to assist in alerting practitioners to view the data to make more timely decisions about intervention. Additionally, these technologies are also including ways to communicate this information to multiple stakeholders such as parents, school support team members, and anyone else involved in the educational process further allowing for tracking of behavior analytic services and generation of billing for insurance agents and government funding bodies.

A Model of Schooling Incorporating ABA as a Teaching Technology

There are several examples of *applications of behavior analysis* in education. In this section we will name and describe one of these models. The intent of such approaches are to make everyone in the system accountable for outcomes. Additionally, the goal is to effectively use the technology of ABA as a means to increase student outcomes. ABA as a model of schooling has a purpose to change socially significant student behavior to a meaningful degree in such a way that the results can be shown to be a result of the instructional procedures applied. Administrators and supervisors are held accountable for the outcomes of teachers who in turn are accountable for student outcomes. This system of accountability allows the learner (i.e. student) to drive the system. Models of schooling that integrate ABA as a teaching technology share the following core features:

1. Regular and ongoing data collection and data analysis
2. Ongoing core teacher training inclusive of regular supervision with corrective feedback.
3. Implementation of over 200 evidence-based teaching strategies, tactics and curriculum that make-up a technology of teaching including but not limited to: Direct Instruction (DI) (Becker, 1977; Becker & Carnine, 1981; Engelmann & Carnine, 1991), Personalized System of Instruction (PSI) (Keller, 1968; Sherman, Raskin, & Semb, 1982), the consulting behavior analyst model (Greenwood, Delaquadri & Hall, 1984), and the Precision Teaching Model (PT) (Lindsley, 1990; Lindsley, 1991).

The Comprehensive Application of Behavior Analysis to Schooling (CABAS®)

CABAS® (Albers & Greer, 1991; Greer, 1994; Greer, McCorkle & Williams, 1989; Ingham & Greer, 1992; Lamm & Greer, 1991; Selinske, Greer & Lodhi, 1991) is a student driven school-wide systems approach that creates a symbiotic relationship between all elements of the school program. The goals and objectives of the school program are constantly changing and adapting based on regular ongoing analysis of relevant student outcome data (Bushell & Baer, 1994). The first CABAS® school; the Fred S. Keller School, was established in 1986 in New York by Dr. R. Douglas Greer. Currently five schools are fully certified by the CABAS® Board in New York, New Jersey, Louisiana, and England while others are in the certification process in Italy, Spain, and other countries. See Figure 1 for an example of the components of a fully certified CABAS® program.[1]

Additional defining features of the CABAS® model include use of the following: The learn unit (Albers & Greer, 1991; Lamm & Greer, 1991; Ingham & Greer, 1992, Greer & McDonough, 1999; Selinski, Greer & Lodhi, 1991) as the smallest unit of instruction, teacher observations using the Teacher Performance Rate and Accuracy Assessment Scale (TPRA) (Ingham & Greer, 1992; Ross, Singer-Dudek & Greer, 2005), decision-tree protocol for data analysis, Preschool Inventory of Repertoires for Kindergarten Assessment (C-PIRK) (Waddington & Reed, 2009) and other curriculum based measures (CBM), CABAS® Teacher Training Modules/ Ranks (Keohane & Greer, 2005) inclusive of verbal behavior about the science, verbally-mediated, and contingency-shaped behaviors, Skinner's *Verbal Behavior* (Skinner, 1954) and Verbal Behavior Developmental Theory (VBDT) (Greer & Keohane, 2005) used to determine student verbal behavior repertoires identifying their verbal capabilities to individualize instruction, a university connection to allow for ongoing learning and provide teacher internships, and CABAS® curriculum/ protocols based on research on effective teaching strategies.

The purpose of this model is to use ABA as a teaching technology to implement an approach to schooling that is focused on the entire system: students, teachers and parents using scientifically driven effective procedures with ongoing learning built in. ABA has more recently and commonly been associated with children diagnosed with an Autism Spectrum Disorder and other such diagnoses that fall under the purview of special education. However, the CABAS® schools have used ABA as a technology of teaching that is also applied to general education with 7 general education classrooms currently using the Accelerated Independent Learner Model (AIL) developed as a means to increase student outcomes in a general education setting. The components of the AIL classroom in CABAS® are detailed in Table 2.[2]

Figure 1. Description of CABAS® program components (adapted from Greer, Keohane, & Healy, 2002, p. 126)

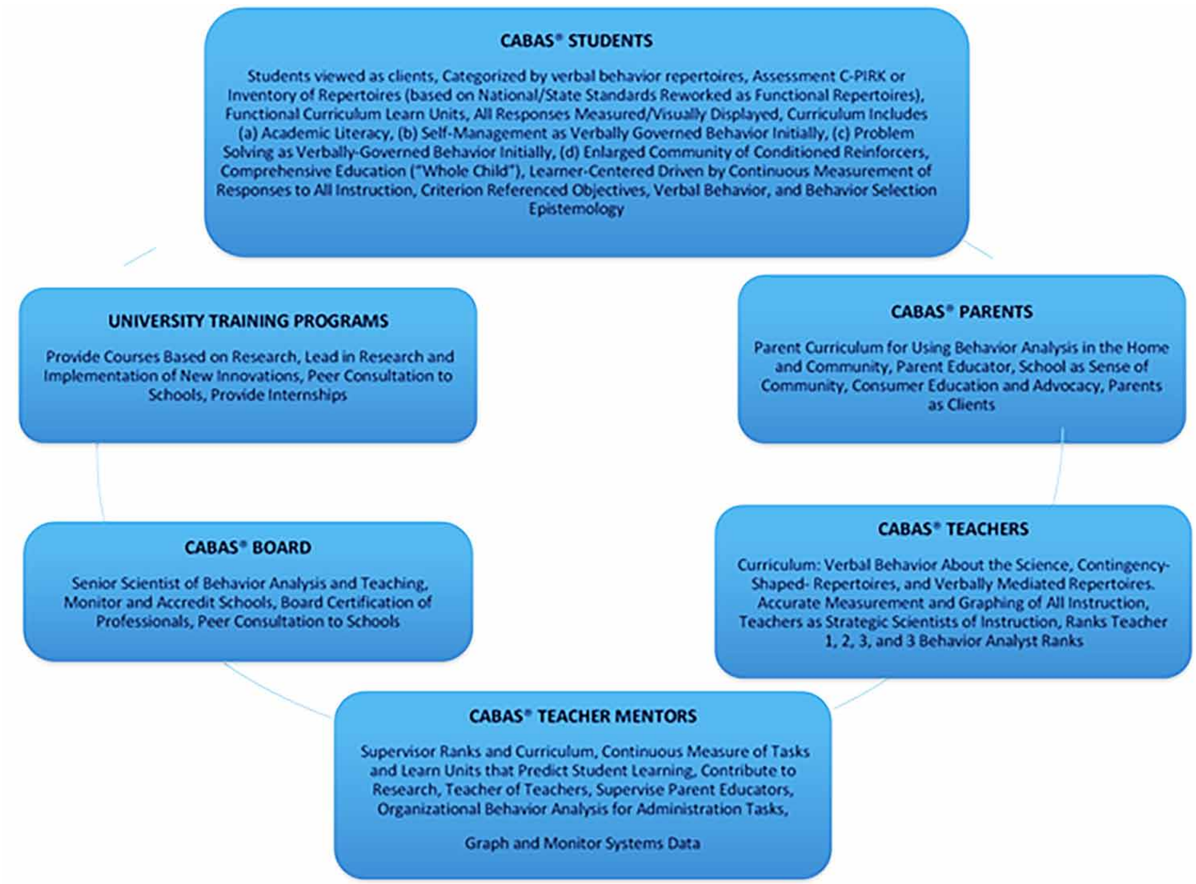

Table 2. Components and instructional procedures of a CABAS® AIL classroom (adapted from Broto & Greer, 2014, p. 9)

a) Learn unit (direct and observed) b) Model demonstration learn units for more advanced students with observational learning (model of how to do the problem followed by probes and learn units) c) Rule posting and reinforcement for following rules d) Point system (individual, small group, and whole classroom) for accuracy and social behavior e) Class wide peer tutoring f) Differentiated instruction by small groups across all academic areas g) Choral responding in small or large groups h) Response board responding i) Mastery objectives followed by fluency objectives j) Personalized System of Instruction (PSI) for advanced students (Keller, 1968; Sherman, Raskin & Semb, 1982) k) The use of book reports to assess students' reading comprehension skills. (The book reports included a summary of events of a story including the beginning, middle, and end, description of characters, and description of story setting) l) Public posting of responses to math facts fluency, reading scores, correct completion of book reports, and class-wide learning data m) CABAS® AIL decision protocol for when interventions are needed and where to locate the source of the learning problem n) Use of Learning Pictures on a web server (showing mastery of objectives in the curricula and numbers of learn units needed to achieve mastery or fluency)

Every person involved in the school including: top level administrators, teachers, teaching assistants and parents are provided with instruction and training in implementing tactics and strategies of applied behavior analysis through a series of training modules. The training modules are set up in a way that allow each staff member or parent to go through them at their own pace using *Personalized Systems of Instruction* (PSI) (Keller, 1968) based procedures.

Fundamental modules required for a minimum standard of practice within the school system are to be completed within a given time frame while others are left at the discretion of the employee. The completion of training modules leads to professional ranks and incremental merit based pay raises. Professional ranks include, but are not limited to,: Teacher 1, Master Teacher, Senior Behavior Analyst and Research Scientist. These ranks are equated to a specific level of expertise and are awarded upon the completion of modules in conjunction with the demonstration of specific skills within the school, home or other required settings across three major teaching behaviors that collectively make up repertoires of a teacher required to effectively implement ABA as a teaching technology that will be described later in this chapter.

Defining Features of CABAS®

The Learn Unit

The learn unit (Albers & Greer, 1991; Lamm & Greer, 1991; Ingham & Greer, 1992, Greer & McDonough, 1999; Selinski, et al. 1991) is a set of inter-locking three-term contingencies for both the student and the teacher. It is the interaction between teacher delivery and student receipt of instruction (i.e., Instructional Antecedents), student/ teacher responses (i.e., Behavior) and outcomes in the form of reinforcement (e.g., praise) and/or corrections (i.e., Consequences) for which learning can then occur. For an in depth definition and examples of the learn unit (Albers & Greer, 1991; Lamm & Greer, 1991; Ingham & Greer, 1992, Greer & McDonough, 1999; Selinski, et al. 1991) see Greer (2002) chapter 2.

Teacher Training and the Teacher Performance Rate and Accuracy Scale

Teacher training is an essential feature in that you cannot effectively use any technology without proper training and guidance. The CABAS® model provides training of teachers that allow for the development of teaching behaviors that lead to repertoires of teachers as strategic scientists described later in this chapter. For this purpose, the CABAS® teaching modules/ranks require mentor teachers to provide modeling, and in-situ training through the use of the TPRA (Ingham & Greer, 1992; Ross, et al. 2005), which is a measure of both teacher and student behavior in the form of learn units (Albers & Greer, 1991; Lamm & Greer, 1991; Ingham & Greer, 1992, Greer & McDonough, 1999; Selinski, et al. 1991).

The TPRA (Ingham & Greer, 1992; Ross, et al. 2005) provides information on both teacher and student correct/incorrect responses and delivery of instruction as correct and incorrect learn units. Additionally, information is gathered about the learning environment such as direct and indirect behavior management in the form of teacher provided praise and other forms of reinforcement to all students. Further the TPRA (Ingham & Greer, 1992; Ross, et al. 2005) requires the teacher to provide information to the observer (i.e., teacher mentor) about the student, teaching procedures, objectives of instruction and under what conditions student responses are to occur (e.g., schedules of reinforcement and other behavior management strategies), as well as operational definitions of the target skills or social behaviors.

Decision Tree Protocol

The decision tree protocol (Keohane, & Greer, 2005) is used as another tool to train teachers how to analyze visual displays of student data (i.e., graphs) and make decisions based on a visual analysis in combination (when more advanced teaching repertoires are gained) with verbally-mediated strategies to decide when and what interventions to implement. In summary, the protocol states that when visually inspecting a graph of student data one should look at the trends in the data to determine: 1) when an intervention is needed and 2) what intervention strategies should be implemented.

Data trends include the following: ascending (i.e., increasing), descending (i.e., decreasing), no trend (i.e., flat), and variable trend (i.e., changes of direction). Once a trend is identified the teacher will determine if the method of instruction should change or remain the same. Additionally, a teacher as strategic scientist would then ask a series of verbally-mediated questions to identify the problem in the learn unit and make a determination about what tactics or strategies would best remediate those problems. For an in depth description of the decision tree protocol procedures see Keohane, & Greer (2005).

Student Assessment

Students are assessed in pre-school using the C-PIRK (Waddington & Reed, 2009) and those at higher grades are assessed using curriculum based assessments tied to national, state or country standards and translated into functional repertoires.

Verbal Behavior Repertoires

Skinner's (1957) treatment of verbal behavior, the *Verbal Behavior Development Theory* (Ross, et al. 2005) and other research that helped to develop such theories of verbal behavior are used to determine a student's current learning needs based on a functional analysis of their verbal behavior repertoire. Students are classified as pre-listeners, listeners, speakers, speaker as own listeners, and readers. Additionally, at more complex stages of verbal behavior students are classified as readers (with mathematical repertoires), writers, writer as own reader, and problem-solvers. Each of these repertoires is characterized by a set of skills that the student currently emits. *Pre-listeners* are completely dependent on those around them for their survival as they are unable to manipulate their environment through their own behaviors. *Listeners* can follow simple directions and with assistance can direct change within their environment. *Speakers* can manipulate their own environment through the mediation of another person (a listener) who can then make necessary changes to the environment that in turn control a speaker's behavior. *Speaker as own listener* is someone who can make changes to their environment through directing a listener and can self-edit their behavior based on the environmental contingencies. Readers can manipulate their environments without the need for a listener as they also have the skills to wait for or recruit reinforcement through the use of written and other verbal behavior repertoires. For an in depth description of each verbal behavior repertoire see Greer, 2002, chapters 5 and 6.

TEACHERS AS STRATEGIC SCIENTISTS OF INSTRUCTION

What is a teacher as a "strategic scientist of instruction" (Greer, 1991; Greer 2002)? As discussed previously in the chapter teachers in the CABAS® system are trained using training modules across three specific behaviors that make up a teaching repertoire: verbal behavior about the science, verbally-mediated behaviors and contingency-shaped behaviors. Teachers are acting as strategic scientists of instruction when they have mastered these teaching repertoires allowing them to speak a common language, effectively replicate evidence-based teaching procedures, ask high level questions about whether instruction is effective or ineffective and make moment to moment decisions about changes to instructional methods and the instructional environment based on an analysis of student data and the student's history of instruction.

As a strategic scientist of instruction these skills are applied in the setting to remediate learning problems. Teachers become "strategic scientists of behavior" when evidence-based procedures are shown to be ineffective with students in their learning environment. The "strategic scientist of behavior" uses the same skills but additionally creates new procedures and tests their effectiveness through functional or experimental analysis in the classroom setting (Greer, 2002).

In order for teachers to master skills required to develop the necessary repertoires to implement ABA as an effective teaching technology they must be carefully supervised. The supervision of a teacher as a strategic scientist of instruction further requires specific repertoires of a supervisor to be discussed later in the chapter.

Teaching Repertoires of Strategic Scientists of Instruction

The CABAS® training modules are constructed based on one major premise. In order for students to succeed people in their learning environments (inclusive of school and home) must speak a common language, provide consistency and support for their learning so that students maintain and apply what they have learned across time and settings (i.e. generalization) as well as become independent learners. The CABAS® training modules are derived from this premise and focus on training the following repertoires of the teacher as a strategic scientist of instruction (Greer, 1991; Greer 2002): verbal behavior about the science, verbally-mediated teaching repertoires and contingency-shaped teaching repertoires.

Verbal Behavior about the Science

The key to any technology of teaching is the common vocabulary or terminology of a science. In order to provide effective instruction educators must first use precise language to name and describe instructional problems. Further educators must also name and describe the teaching tactics and strategies that will remediate those instructional problems. To this end a common language allows educators to contact educational and behavioral research, understand what is read, and translate that information to others in the student's learning environments resulting in the development and implementation of effective instructional procedures to remediate specific learning problems. Furthermore, teachers and parents can then access the greater community of educators and behavior analysts in a way that allows for ongoing professional development and training opportunities to occur.

Contingency-Shaped Behavior

Speaking a common language through the use of a similar technical vocabulary is not enough. Teachers and parents must also replicate evidence-based teaching procedures in the classroom and home. This repertoire allows the teacher to use the verbal behavior about the science to contact the research literature in education and behavior analysis and systematically follow the procedures given in their own setting. When a teacher has gained these skills they should be able to consistently apply evidence-based procedures in the classroom. However, additional skills will be necessary for those behaviors that are not affected by the mere implementation of such procedures. As we know there are multiple variables that may act as barriers to students accessing the curriculum or changing behavioral patterns. In order for teachers to be effective in addressing behaviors resistant to change they must gain additional skills.

Finally, teachers must learn to, "go with the flow" so to speak. They must evaluate student performance on a regular basis (i.e., daily) to determine whether students are responding favorably to instruction or not. In the case they are, teachers must stay the course. In the case they are not, teachers must quickly and effectively make changes to instruction to engage students in ways for learning to occur or behaviors to come under control of the learning environment. This requires teachers to design instruction based on direct assessment of students, use scripted teaching procedures and be ever present and responsive to students by providing: flawless instructional antecedents, reinforcement for appropriate responses/behaviors, and behavior specific corrective feedback in order to increase correct responding and decrease student errors (Greer, 1991).

Verbally-Mediated Behavior

To speak a common language and to successfully replicate evidence based procedures in the instructional setting are necessary first steps in effectively using ABA as a teaching technology. However, in order to truly provide for ongoing effective use of such a technology one must be able to remediate instructional problems that have been resistant to change or the effects of evidence-based procedures. This is done by asking high level questions about instructional problems in order to identify and remediate them (Keohane & Greer, 2005). Some examples of verbal-mediation include asking the following types of questions: Is this learning problem due to the student's history of instruction (i.e., prerequisite skills? ability to respond to the instruction? environmental arrangements? presentation of the material? opportunities to respond to instruction?) or barriers to contacting instructional antecedents such as attention and/or behavioral issues?

Answering these types of questions allow teachers as strategic scientists of instruction to use the technology of ABA to make informed decisions about the appropriate strategies to remediate learning problems based on their interaction with the student and learning environment. Teachers can then make adjustments to their teaching, student response modalities, classroom environments and/or positive behavioral supports to ensure the removal of instructional barriers and increase the opportunity for learning to occur.

Supervision for Training Teachers as Strategic Scientists

In order for teachers to become strategic scientists of instruction they need to become fluent in the three teaching behaviors discussed throughout this chapter. To this end training requires direct instruction in all three teaching behaviors. To build a repertoire as a strategic scientist the following behaviors must be learned and demonstrated to a mastery and/or a fluency criterion. This is done for verbal behavior about the science by reading and learning definitions of the terminology of the science. Teachers take quizzes and recycle to a mastery criterion until they become fluent in the verbal behavior about the science. They begin with basic terms required for initial stages of ABA as a teaching technology (e.g. basic behavioral principles of reinforcement and punishment) through more complex terms that define and describe teaching strategies and tactics to remediate learning problems (e.g., differential reinforcement of alternative behaviors and behavioral shaping and chaining procedures).

Contingency-shaped behaviors are taught through in-situ modeling and supervision with corrective feedback in the form of a TPRA (Ingham & Greer, 1992; Ross, et al. 2005) completed in the classroom or other learning environment. One demonstration of fluency in this area requires a teacher to deliver intensive and flawless learn units (Albers & Greer, 1991; Lamm & Greer, 1991; Ingham & Greer, 1992, Greer & McDonough, 1999; Selinski, et al. 1991) in the classroom with high rates of student accuracy of responding over a period of time. Additional demonstrations of mastery and fluency in this area require ongoing adaptations to the classroom environment through daily classroom routines and procedures such as delivering reinforcement for student pro-social behaviors and rule-following while ignoring or implementing procedures to change maladaptive behaviors. This also requires the ability to make in the moment changes to instructional procedures as needed.

Verbally-mediated behaviors are taught through an ongoing analysis of visual representations of both student and teacher data using high-level questions to determine instructional problems, name and describe tactics and strategies to remediate them as well as develop proactive solutions for possible learning barriers. Verbally-mediated behaviors are demonstrated through a supervisor's' review of student visual data (i.e., graphs).

Supervisors themselves must have mastered these teaching repertoires in order to train others. They use tools such as the TPRA (Ingham & Greer, 1992; Ross, et al. 2005) to measure learn units (Albers & Greer, 1991; Lamm & Greer, 1991; Ingham & Greer, 1992, Greer & McDonough, 1999; Selinski, et al. 1991) consisting of: teacher delivered instruction in the form of instructional antecedents, student responses to instruction (i.e. student behavior), and teachers correct or incorrect application of student reinforcement for correct responses or student corrective feedback as consequences for incorrect student responses to teacher led instruction. The TPRA (Ingham & Greer, 1992; Ross, et al. 2005) allows an in depth analysis of complete flawless presentations of the *learn unit* (Albers & Greer, 1991; Lamm & Greer, 1991; Ingham & Greer, 1992, Greer & McDonough, 1999; Selinski, et al. 1991). The *learn unit* is considered the smallest unit of instruction and a complete learn unit is a requirement for learning to occur (Albers & Greer, 1991; Lamm & Greer, 1991; Ingham & Greer, 1992, Greer & McDonough, 1999; Selinski, et al. 1991).

In CABAS®, students drive the system through teachers and administrators regular and ongoing analysis of relevant student outcome data (Bushell & Baer, 1994) in the forms of total delivered and correct learn units, learn units to mastery criterion, number of objectives met, increases in prosocial behaviors, decreases in maladaptive behaviors as well as the development of more independent and complex student verbal behavior repertoires. A combination of high rates of correct teacher decisions based on the decision tree protocol, low rates of teacher errors and high rates of correctly implemented learn units (Albers & Greer, 1991; Bahadourian, 2000; Lamm & Greer, 1991; Ingham & Greer, 1992, Greer & McDonough, 1999; Selinski, et al. 1991) as measured by the TPRA (Ingham & Greer, 1992; Ross, et al. 2005), combined with the other CABAS® components show a cumulative effect of higher rates of student learning overall as measured in decreased numbers of learn units to criterion, the increased high rates of correct and low rates of incorrect teacher decisions and student responses to instruction, as well as gains on standardized, and criterion referenced assessments show the system to be an extremely effective one (Greer et al., 2002; Singer-Dudek, Speckman, & Nuzullo, 2010).

The student outcome data is reflexive of the extent of teacher effectiveness and leads to school-wide goal setting both academically and from an operations perspective. This information relayed in the form of schoolwide evaluative data allows administrators to: set schoolwide goals, determine training needs and remediation for specific classrooms, teaching staff, and students as well as make adjustments to tuition fees, teacher salaries, etc. This level of data collection and analysis additionally allows for a cost-benefit analysis through the determination of actual cost per student goal achieved (Greer, 1994a; Greer, 1994b; Greer, Keohane & Healy, 2002). This leads to effective data based decision making that benefits everyone in the system from students to the local taxpayers.

CONCLUSION

In conclusion, there are a number of specific examples that exist as evidence of the ability of ABA to offer an endogenous technology that is essential and critical to support the development of humans as learners when combined with exogenous technology in this digital age. The authors have briefly reviewed several of those examples, both practical examples of teacher skills and real life examples of the successful use of these strategies and tools in classrooms and schools.

One of the major areas of focus that the authors recommend in order to improve the effectiveness of schools and in turn student outcomes is to increase training of teachers in the use of educational technologies afforded us from the behavioral sciences. The President of the United States himself has issued an executive order, Executive Order No. 13707 (2015), supporting the use of behavioral science to improve lives and to improve the access to educational opportunities for all. Training teachers to use ABA as a teaching technology is one way in which we can meet this mandate. The authors feel ABA as a science is important for educators to use in order for them to leverage the advances we have seen in the digital age to contribute to advances in human development and learning which will be necessary if we are to prepare our children to be successful in the modern world.

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KEY TERMS AND DEFINITIONS

Applied Behavior Analysis: The application of evidence-based intervention strategies used to change socially significant behaviors to a meaningful degree such that the interventions applied can be shown through experimental manipulation to be responsible for the change of behavior that occurred.

Exogenous Technology: Hardware, software, and other downloadable applications for use on computers, smartphones, or tablets used for advancing learning and/or assisting in behavior change.

Response to Intervention: A multi-tier approach to identify students who require academic, social and behavioral interventions in general education classrooms and school settings. The effectiveness of such interventions subsequently measured to determine the need to refer the student for additional academic, social and/or behavioral supports via special education services.

Operant Conditioning: A type of learning that occurs through the consistent application of a set of consequences in relation to antecedent stimuli. This is done using the principles of behavior: positive reinforcement, negative reinforcement, positive punishment and negative punishment.

Task Analysis: The observation of a competent individual or group completing a task for the purposes of breaking the skill down into smaller components to teach a novice.

Shaping: Differential reinforcement (i.e. application of behavioral principles of reinforcement and punishment) for successive approximations to a terminal behavior such that some responses are reinforced while others are punished leading to the accurate behavior being emitted by an individual.

Modeling: Providing visual examples of an individual or group performing a skill or set of skills accurately and fluently for the purposes of teaching others through the visual medium.

Behavior Chaining: A chain of complex behaviors broken down into small incremental steps that build upon each other to complete a task at varying levels of difficulty. Each step in the chain builds upon the other serving as both antecedent and consequence to student behaviors. Each step is differentially reinforced resulting in a completed task. (e.g. reciting the alphabet or brushing one's teeth.)

Discrete Trail Training: The delivery of instruction that breaks down each unit of teaching into a three-term contingency such that there is a teacher delivered antecedent followed by student behavior and teacher applied consequence as a means of delivering individualized instruction.

ENDNOTES

1 CABAS® is a registered trademark of R. Douglas Greer. The circular pattern represents the symbiotic relationship between all components of the system. Adapted from Greer, R.D., Keohane, D., & Healy, O. (2002). Quality and comprehensive applications of behavior analysis to schooling. *The Behavior Analyst Today, 3*(2), 120.

2 Reproduced from Broto, J., & Greer, R.D. (2014). The effects of functional writing contingencies on second graders' writing and responding accurately to mathematical algorithms. *Behavioral Development Bulletin*, *19*(1), 7.

APPENDIX

Foundations of ABA

Operant Conditioning

Operant conditioning is a key process of changing behavior. Its theoretical basis is from Skinner's experimental analyses of behavior which were conducted in his research laboratories from the 1930s to the 1950s (Cooper, et al., 2007). Skinner (1938) formulated principles of behavior from his experiments. The behavioral principles (i.e., reinforcement, punishment, stimulus control, etc.) describe relationships between environmental conditions and the behavior of organisms subject to those conditions.

Operant conditioning is a behavioral technology in which behavioral principles of reinforcement and punishment are key elements of the process (Cooper et al., 2007). It describes the selective effects of consequences which follow behavior and influence its future occurrence. However, functional relationships between behavior and the consequences that follow the behavior are also associated with antecedent conditions (events preceding the behavior). Operant conditioning is a term used to describe "learning." Operant conditioning occurs when a three-term contingency of antecedent, behavior, and consequence events repeated together can accurately predict behavior. When an organism comes under the control of this three-term contingency we say that "learning" has occurred. Therefore, learning occurs when antecedent stimuli (a stimulus or condition occurring prior to a predicted behavior) becomes a discriminative stimulus (S^D) for the occurrence of a specified behavior or set of behavioral responses. This behavior and or set of behaviors regularly comes into contact with a specified consequence or consequence event which either reinforces the behavior (i.e. increases the probability of future occurrence), or punishes the behavior (i.e. decreases the probability of future occurrence). The S^D is repeatedly presented until the three-term contingency becomes a discriminated operant to an individual.

Operant conditioning, when used as an educational technology, entails assessment of specific, observable, measurable behaviors, operationalized behavioral intervention to change behaviors, and progress monitoring through ongoing data collection and analysis. In order to target appropriate skills to teach or behaviors to improve it is imperative to assess current student repertoires. In the next section the authors will discuss behavioral assessment and how ABA offers ways of teaching new behaviors, maintaining behaviors, and reducing unwanted behaviors.

Behavioral Assessment

Typical psycho-educational assessments involve norm- and/or criterion-referenced standardized tests. The main purpose of those types of assessments is to find an individual's strengths and weaknesses by comparing his/her skill levels in assessed domains with those of a normed group (Cooper et al., 2007). Skill-based assessments offer a complete picture of an individual's current repertoires, upon which an individualized instruction can be built for more advanced learning to occur. Typical psycho-educational assessments and skill-based, or performance-based, assessments serve to answer specific types of questions about the learner. They can tell us about how the learner performs compared to his/her peers and they can tell us how the learner's skills in one area of learning are compared to their skills in another area of learning.

Behavioral assessments are designed to ask questions about how the learner's behavior relates to operant principles. The purpose of behavioral assessment is to identify behavior targeted for change and, equally importantly, to identify antecedent conditions and consequences which establish and maintain the behavior. Antecedent conditions and consequences are environmental variables that increase or decrease the future probability of a behavior and, further, are important, too, for maintenance and generalization of the induced behavior change. Identification of those variables; especially those for problem behavior, often requires a variety of methods including: interview, checklists, and direct observation.

Through a comprehensive behavioral assessment and an understanding of the contexts where the behavior occurs, reinforcers and competing contingencies for the behavior of interest can be identified. Thus behavioral assessment provides information about the behavior and how to change it (Cooper et al., 2007). Behavioral assessment identifies current operant behaviors and competing contingencies. It also provides information about how to change the operants including alternative contingencies. Behavioral assessment enables us to make scientifically and ethically appropriate decisions whereby a behavior change can be induced successfully and effectively (Mayer, Sulzer-Azaroff, & Wallace, 2012). The fol-lowings are brief examples of behavioral assessment:

Classroom Scenario 1

A kindergarten teacher, Sara, wants to know whether Jim, who struggles to make friends, greets his peers when he meets them. First she interviews a teacher's aide who stays with Jim during lunch time and recess. Sara also interviews Jim's mother to gain relevant information within and about his community settings. Through the interviews, Sara learns that Jim raises his hand without smiling or saying anything when he sees his peers. More detailed information is revealed when Sara directly observes the behavior of interest. Jim raises his hand too far away from his peers for them to recognize him. Jim doesn't say hello to his peers when they are near him.

With information gathered through the assessment, Sara identifies problems within the three-term contingency that cause barriers to appropriate socialization with peers. A potential intervention is se-lected to teach the necessary operant while applying the principles of reinforcement to correct the faulty operant (i.e., learned behavior), and to provide support to people in his social environment. Sara decides to provide prompts to Jim to greet peers when in close proximity. Additionally, she provides prompts to teach an appropriate distance from which to wave hello. When he engages in the behaviors with guid-ance, prompts are removed (i.e., faded) until the behavior comes under control of the proximity of peers.

Classroom Scenario 2

Ethan is a fourth grader in an integrated classroom of a public school. He has been referred for a func-tional behavior assessment due to his aggressive and disruptive behaviors in class. Ethan yells, swears at the teachers, and sometimes sweeps things off his desk when he is required to complete tasks in class. Ethan's behavior usually occurs during literacy and history class. His behavior interrupts the learning of himself and his peers. A behavior analyst conducts a comprehensive assessment including: reviewing documents, interviewing relevant adults, practitioners and/or peers, using a checklist and/or behavior rating scale, and direct observation. The assessment reveals that Ethan needs help with tasks where he is required to process auditory input. Results of the assessment suggest that his aggressive behavior is to communicate a need for help or a break when frustrated. "I need help" or "I need a break."

The assessment has provided information about the faulty operant (e.g. antecedent = task demands, behavior = yelling, reinforcement = teacher attention and escape). The assessment further provides information about alternative replacement behaviors (i.e., newly targeted operant behavior), resources within school, key people involved, and supporting personnel. Based on the results of assessment, an effective intervention is implemented. The intervention includes preparing environmental supports such as the use of visual aids and additional time to complete tasks, a system of reinforcement for his completion of tasks, extinction strategies (i.e., withholding reinforcement for previously reinforced behaviors) to make the current operant ineffective, and reinforcing alternative socially acceptable behaviors (e.g. saying, "I need help" and/or "I need a break"). The assessment is also a basis for monitoring and experimentally analyzing the function of the intervention plan and its outcomes.

Teaching New Behavior

When making a decision about what behavior to target for change considerations need to be made about how effectively the behavior change will induce adaptive and habilitative outcomes for an individual (i.e., social significance) (Cooper, et al., 2007). An observable and measurable definition of target behaviors to teach; often referred to as a "behavioral objective," is the first step when teaching a new behavior.

Ongoing progress monitoring through data collection on the target behavior provides a basis for analyzing the effect of a teaching procedure and allows the professional to test for function which is a core feature of a scientific technology. For example, you may want to increase reading fluency. The problem with stating this as a student goal when writing objectives for students with learning differences on an Individualized Education Plan (IEP), Accelerated Learning Plan or Response to Intervention (RTI) is that there is no way to observe and measure this behavior. In education it is vastly important to write student goals and objectives in a way that allows one to determine whether or not the teaching strategies and methods of intervention are effective.

Teaching strategies are considered effective if the student masters the material taught. To increase reading fluency is very vague and difficult to measure. However, when written as a behavioral objective the goal reads: Given a leveled reader (stimulus) and the teacher direction to, "read" (antecedent) the student will read 20% more words per minute read (method of measurement) over initial baseline measures with 90% accuracy (criterion) for pronunciation, additions and omissions (student behavior).

The teacher in the setting will then provide reinforcement for correctly read words and consequences in the form of corrections for any additions, omissions or mispronounced words (consequence). This breakdown of antecedent stimuli, student behavior and teacher consequence constitute the three-term contingency of operant conditioning (i.e. teaching). For "good" teachers this is a naturally occurring condition in the classroom when working with students. The behavioral objective; consisting of the three-term contingency, method of measurement and criterion to meet the objective, of increasing reading fluency can then be measured and teaching strategies therefore found effective or ineffective.

The criterion for improvement can be incrementally increased over the course of the school year such that it begins with 20% and ends with 75% over baseline measures resulting in the student reading at a pace 75% faster or more fluent than when initially tested. As a matter of course these figures are not chosen arbitrarily. A measure of student's word per minutes read will be based on the "norm" for the age/grade level of the student and/or their class peers.

As you can see from the previous example teaching a new behavior involves behavioral pedagogy. A core procedure of behavioral pedagogy is operant conditioning. A targeted and thus potential operant is presented until learning occurs and the potential operant becomes a discriminated operant. The potential operant consisting of the three-term contingency is the main agent for learning to occur.

Through the operant conditioning procedure, the individual establishes a history of reinforcement within the three-term contingency. The identification of reinforcers is a major component of the process of operant conditioning. Through preference assessment and reinforcer assessment, potential reinforcers can be identified (DeLeon, Iwata, Goh, Worsdell, 1997; Fisher, Piazza, Bowman, Hagopian, Owens, & Slevin, 1992; Pace, Ivancic, Edwards, Iwata, & Page, 1985; Piazza, Fisher, Hagopian, Bowman, & Toole, 1996).

Reinforcers for an individual can be primary, secondary or tertiary. Primary reinforcers include food or physical contact, those things that are part of human phylogeny (i.e. built into the system- DNA), and secondary reinforcers (requiring some training after birth) include a variety of environmental stimuli such as toys, activities, and events. Praise, tokens, and even money are generalized reinforcers with which different response classes can be taught. It is important for educators to understand that verbal praise alone does not always act as a reinforcer for students. Many students are shy or dislike public attention therefore student preference and reinforcer assessments are strongly encouraged as the use of verbal praise alone to reinforce student behavior is not always adequate for them to learn new operants.

Another important element of the three-term contingency delivered during operant conditioning is the antecedent condition. When a response-reinforcer relation is associated with an antecedent condition, the three-term contingency becomes a discriminated operant. Thus, identifying whether an additional antecedent stimulus is needed and what type of stimulus that might be is critical in the operant conditioning process. Providing an additional stimulus to a natural antecedent stimulus is technically known as prompting.

For example, a young child may need a hand gesture or vocal signal (i.e. prompt) when he/she is required to discriminate a tiger from a lion initially. A mother might point to a lion asking her child, "Where is a lion?" when they look at an animal book together. A picture of a lion (stimulus) and mom's asking, "Where is a lion?" (antecedent) together are antecedent stimuli and gesturing to the picture is an additional stimulus or prompt. Later, the gesturing can be removed once the child reliably points to the picture of the lion. Eventually, the child will be able to point to the picture of a lion without the additional stimulus (i.e., prompt). This procedure is referred to as prompt fading and transfer of stimulus control. In this case, with the aid of an additional antecedent stimulus the child is exposed to the potential operant easily and learning is induced more efficiently.

These prompts include physical guidance, instructing, modeling, and vocal prompts (Alberto & Troutman, 2013). Using technical terms for this process allows the professional to teach others to engage in the same teaching process with precision and accuracy.

Modeling

Modeling is one of many widely used prompt procedures for establishing a variety of behaviors. A physical movement may function as a model when it evokes an imitative behavior of a child which brings about acquisition of a new skill. In that case, a model is an antecedent stimulus that functions as a prompt. For example, seeing a jungle gym alone won't evoke appropriate play when a child sees it for the first time. The child will learn how to play on the jungle gym after the child observes and imitates others' actions on the jungle gym.

Video modeling emerged in the 1990s as an effective tool to teach new skills (Wilson, 2013). For example, video modeling was used to teach functional living skills, social-communication skills such as toy play or social initiations (Shukla-Mehta, Miller, & Callahan, 2010; Simpson, Langone, Ayres, 2004). Shrestha, Anderson and Moore (2013) taught a 4-year old boy to prepare and serve himself Weetabix. Thirteen steps for setting-up, eating, and cleaning -up were identified and three videos were produced with the boy's mother as the model.

The first video included Steps 1-4 which began with the model saying, "I'm hungry! Let's get some Weetabix without any help!" The second video included Steps 1-10 and the third one included Steps 1-13. The results of using video modeling in teaching the self-help skill indicated that the modeling procedure was effective and the learned skill was maintained. The 13 steps identified are shown in Figure 2.

It should be noted that often, providing prompts is not enough to induce learning of a new skill. For example, it is unrealistic for a young child to draw a triangle with straight lines when they connect two dots with a curvy line. In this case, shaping can be a useful strategy.

Figure 2. Task analysis for the target behavior using a video model (adapted from Shrestha, Anderson, & Moore, 2013)

Steps	Phases		
1.) Get a bowl from the drawer			
2.) Get a spoon from the drawer	Phase 1		
3.) Get Weetabix from the cupboard			
4.) Get soy milk from the fridge			
5.) Put two Weetabix in the bowl			
6.) Open the lid of the milk bottle			
7.) Pour some milk in the bowl just enough so the Weetabix can still be seen.		Phase 2	
8.) Close the lid of the milk bottle			
9.) Break the Weetabix up			
10.) Eat			Phase 3
11.) Take the bowl over to the sink			
12.) Put the Weetabix back in the cupboard			
13.) Put the milk in the fridge			

Shaping

Shaping is defined as "the process of systematically and differentially reinforcing successive approximations to a terminal behavior (Cooper, et al., 2007, p. 421). Through differential reinforcement for drawing more straight lines in the triangle, the child draws a triangle with less curvy and straighter lines. The strategy is used until the child produces an acceptable triangle.

Shaping can be used for a child who can't sit even a minute to teach sitting for 15 minutes. A certain length of time sitting is reinforced selectively during each stage of shaping and gradually, the length of his sitting behavior is shaped up to 15 minutes. Again, the professional can more effectively apply this strategy when it is treated as a technology.

Case Example 1

A special education preschool teacher Martha has a 4-year old boy Ethan who has feeding problems in her classroom. Ethan would not accept any food delivered on a spoon. In addition to that, he has no history of swallowing food with texture. The main source of his nutrition was in liquid form such as

Table 4. Three-term contingency to shape feeding behaviors

Step	Antecedent	Behavior	Consequence
1	A spoon with a small amount of oatmeal & teacher gesture to the spoon	Bring the spoon to his lip within 10 seconds	Video for 30 seconds
2	A spoon and tray with oatmeal	Put the spoon in his mouth within 10 seconds	Video for 30 seconds
3	A spoon and tray with oatmeal	Put the oatmeal in his mouth and swallow within 10 seconds	Video for 30 seconds
4	A spoon and tray with a spoonful of oatmeal	Scoop and put the oatmeal in his mouth and swallow within 10 seconds	Video for 30 seconds
5	A spoon and tray with a spoonful of oatmeal	Finish the oatmeal within 1 minute	Video for 30 seconds
6	A spoon and tray with 2 spoonfuls of oatmeal	Finish the oatmeal within 1 minute	Video for 30 seconds
7	A spoon and tray with 3 spoonfuls of oatmeal	Finish the oatmeal within 1 minute	Video for 1 minute
8	A spoon and tray with 5 spoonfuls of oatmeal	Finish the Oatmeal within 5 minutes	Video for 3 minutes
9	A spoon and a tray with 5 spoonfuls of oatmeal with 1/10th slice of bread mixed	Finish the oatmeal within 5 minutes	Video for 3 minutes
10	A spoon and tray with 5 spoonfuls of oatmeal with 3/10ths slice of bread mixed	Finish the oatmeal within 5 minutes	Video for 3 minutes
11	A spoon and tray with 5 spoonfuls of oatmeal and a 1/10th slice of bread separate	Finish the oatmeal and the bread within 5 minutes	Video for 3 minutes
12	A spoon and tray with 5 spoonfuls of oatmeal and a 3/10ths slice of bread separate	Finish the oatmeal and the bread within 5 minutes	Video for 3 minutes

PediaSure®. Martha decided to teach Ethan a critical skill, feeding himself textured food using a spoon. First, she interviewed Ethan's mother to ensure that he didn't have a medical reason causing his inability to swallow food with texture. She then broke down the target skill into small steps (i.e. a task analysis). The steps are shown in Table 4.

Martha established criteria for moving from one step to the next: independent responses with 90% accuracy for three to 12 consecutive sessions depending on the target responses. One session is consisted of 1 to 20 trials depending on the target responses. Once Ethan maintained learned feeding responses for 10 school days, Ethan's mother tried to generalize the responses at home very carefully following Martha's guideline. When teaching feeding skills, data were collected and summarized in a graph. Martha monitored the effectiveness of her teaching procedure by regular visual inspection of the graph and received consultation as needed from a supervisor.

Martha realized that she needed reinforcers of very high value to Ethan. Martha used Ethan's favorite video as a reinforcer for his correct responses during the feeding sessions. For example, she gestured to a tray where she placed a spoonful of Oatmeal and waited for 1 minute. If Ethan ate the food on the tray using the spoon, she marked "+" on her data sheet and provided reinforcement by turning on the video Ethan selected on an iPad™ for 1 minute. If he didn't eat within 1 minute, the tray and the iPad™ were removed for 10 seconds. Ethan had another opportunity after a 10-second pause.

The amount and texture (i.e. solidity) of the food was gradually and carefully increased. Finally, Ethan could feed himself foods with soft textures such as oatmeal and bread. Martha realized that teaching feeding required careful monitoring and persistence. Martha still had a long way to go, but Ethan's mother was very happy with the outcome.

Behavior Chaining

Behavior chaining is another useful technology and is used to teach complicated skills which require a sequence of discrete responses. "Each response in a chain produces a stimulus change that simultaneously serves as a conditioned reinforcer for the response that produced it and as a discriminative stimulus for the next response in the chain" (Cooper et al., 2007, p. 435).

One example of behavior chaining is making a peanut butter sandwich. The first response is to place two slices of bread on a plate, which is a discriminative stimulus for the next response, opening a jar of peanut butter. A series of specific discrete responses lead to a terminal response, having a peanut butter sandwich ready on the plate. In behavior chaining, a task analysis is an important component. "Task analysis involves breaking a complex skill into smaller, teachable units, the product of which is a series of sequentially ordered steps or tasks" (Cooper et al., 2007, p. 437).

For example, a parent can teach his/her child to brush their teeth by using a behavior chaining procedure with a task analysis. The parent breaks down steps for brushing teeth into smaller units and teaches the child to perform each of the behaviors in the chain in a specified order. This contributes to the parent behaving as a technologically savvy teacher--a goal the authors would have for any parent.

Maintaining Behavior

Any behavior changed through operant conditioning is not maintained by itself without a persisting behavioral consequence (Malott, Malott, & Trojan, 1999). When a behavior analyst or teacher as strategic scientist teaches a new skill by delivering potential three-term contingencies to a student, he/she might use a continuous schedule of reinforcement by delivering a reinforcing consequence for every correct response. Once the child begins to emit correct responses, the behavior analyst fades the schedule of reinforcement by using a gradually intermittent schedule until it approximates the "natural" environment.

For example, a third grader, Jake is receiving special education services. He is integrated into a general education classroom for 50% of his school day. Jake receives verbal praise from an adult every time he follows a direction in his special education class. One of his behavioral objectives is following directions with an intermittent schedule of reinforcement. The special education teacher expects that Jake will maintain his direction-following after the teacher systematically reduces her delivery of verbal praise. This schedule fading (i.e., schedule thinning) will help him gain skills needed to spend greater amounts of time in the inclusive setting where he may experience fewer opportunities to be praised by his teacher.

The maintenance of learned behavior is influenced by the amount of and types of reinforcers used during operant conditioning. If Jake, in the above scenario, doesn't follow directions with verbal praise alone, the teacher may need to use other prosthetic reinforcers such as cookies or toys at the initial stage of training. Eventually, this type of reinforcer will need to be faded to a natural reinforcer for following directions such as receiving praise or acknowledgement from teachers or finding reinforcement in completion of the task alone. This fading process is another example of a teaching technology as many learners will need systematic support to transition from one type of learning environment, set of expectations, or type of reinforcement to another.

Based on the same behavior principles, problematic behavior that is maintained by intermittent (i.e. variable) schedules of reinforcement also persist and last longer than behavior with continuous schedules of reinforcement (Cooper, et al., 2007; Malott et al., 1999). This is one of the greatest challenges and poses the most difficulty when there is an inconsistent application of an intervention strategy for either teaching a new skill or reducing a problem behavior.

The student continues to behave in ways that have been reinforced in the past due to what is referred to as an "instructional history". The longer the instructional history (i.e., history of reinforcement that maintains a behavior); be it academic, social, or maladaptive, the longer the behavior will persist in the face of changing intervention strategies.

This may at times lead to teachers feeling as though the intervention strategies are ineffective and they may choose to change direction too soon. On the bright side; when teaching a new skill, intermittent (i.e., variable) schedules of reinforcement increase the probability that the behavior will persist (i.e. be maintained). Over time a new skill becomes the norm or expected behavior. The student is now reinforced by the naturally occurring contingencies such as completing an assignment. This is called *transfer of stimulus function*.

A prosthetic reinforcer is no longer needed to reinforce student behavior. When this occurs there is no need to provide the same levels of reinforcement for the same behavior as used when initially teaching the skill. This form of fading is one of many behavioral strategies used in academic interventions such as scaffolded instruction. As new skills are being taught different levels of guidance, prompting or additional tools are provided to the student. These levels of modeling, guidance and use of tools become part of a student's repertoire which are then maintained as new skills are being acquired and build upon the prior knowledge or skill.

Generalizing Behavior

Generalizing behavior requires that the behavior learned in one environment (e.g., school) also has reinforcement provided by other significant people in the student's life in settings where the behavior should also occur. This is the definition of social significance.

If a behavior is learned in one environment or can only be elicited by one person there is no opportunity for the change in behavior to significantly change the person's access to higher instruction and or access to appropriate social experiences. For example, when you first teach a child to use a graphic organizer to organize their ideas before writing you may model its use, prompt them to place items in different categories and other such procedures while providing verbal praise for using the graphic organizer. Over time you reduce the number of prompts, provide less guidance and verbal praise is no longer necessary for the student to use a graphic organizer in the pre-writing stages. If the same is done at home by parents the student will then generalize those skills to home when doing homework allowing them to become more independent and complete work outside of school independent of tutors or adult prompting.

Reducing Behavior

Problem behaviors are also operants which are learned and maintained by environmental effects produced by the problem behavior. In other words, problem behaviors are maintained due to functions of the behaviors within an individual's environment. Simply speaking, problem behaviors are maintained because they serve some purpose or function. An individual may obtain attention they don't regularly receive or avoid having to complete a difficult task (an aversive condition). These types of consequences can lead to problem behavior.

Reducing problem behavior is another area where a technological approach is just as effective as the technological approach to assessment of behavior and the learning of new behavior. Relevant literature reports that environmental events such as social attention, aversive tasks, tangible items, or sensory stimulation (Iwata, Pace, Dorsey, Zarcone, Vollmer, Smith, et al., 1994) can be related to problem behavior. Prior to determining an intervention, a functional behavior assessment (FBA) to determine the relevant environmental events is required.

The main purpose of an FBA is to identify functions of the behavior; setting events (things occurring prior to any antecedent stimuli not necessarily under control of anyone in the environment (e.g., hunger, illness, restless night), antecedent conditions including antecedent stimulus or stimuli and consequences (i.e., environmental changes which follow the behavior). Once the function of the behavior has been determined practitioners can effectively alter three-term contingencies of the problematic behaviors to socially acceptable behaviors with the same functions (Iwata, Dorsey, & Slifer, 1994).

FBA procedures can be classified into three types: (a) indirect assessment, (b) descriptive assessment, and (c) functional analysis which requires experimental manipulations to identify function(s) of the behavior (Cipani & Schock, 2007). Indirect assessment involves interviews, checklists, rating scales, or questionnaires to obtain information to identify possible functions of the behavior within natural contexts from caregivers or stakeholders. This type of assessment is easy to conduct but is limited in accuracy.

Descriptive assessment involves direct observation of the problem behaviors within natural environments to identify relevant three-term contingencies. Main procedures of this type of FBA are ABC recording and scatterplots. ABC recording enables practitioners to make a hypothesis about three-term contingencies (antecedent-behavior-consequence) relationships of the behavior. Scatterplots provide a temporal pattern for the occurrence of the behaviors. Functional Analysis (FA) involves systematically manipulating antecedent events and consequences of the problem behaviors. One advantage of using FA is more accurate information about three-term contingencies involved. However, it requires personnel with extensive training on FA. All of these types of assessment procedures serve one function: identification of three-term contingencies of problem behaviors (Iwata, Dorsey, et al., 1994).