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ENVISIONING EDUCATION 3.0: THE FUSION OF BEHAVIOR ANALYSIS, LEARNING SCIENCE AND TECHNOLOGY

VISLUMBRANDO LA EDUCACIÓN 3.0: LA FUSIÓN DEL ANÁLISIS DE LA CONDUCTA, LA CIENCIA DEL APRENDIZAJE Y LA TECNOLOGÍA

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Abstract

Worldwide the explosion of digital technologies of all forms puts us in the midst of a revolution in education, across both K-12 and university environments. The use of technology-powered learning holds great promise as an efficacious and egalitarian means to help increasing numbers of people (young and old) obtain or accelerate learning and meet challenges in a changing, competitive world. This transformation in how we view and do education has been referred to as Education 3.0, due to its interactive, self-learning, and personalized nature. Features include omnipresent adaptive digital environments and experiences and the ability of programs to self-learn and precisely adjust to the individual learner. Components such as personalized learning and competency-based education share critical features with behavior analysis. This article highlights the congruence between Education 3.0 and behavior analysis, and the opportunity for behavior analysts to create change.

Keywords: behavior analysis, technology, educational innovation

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Resumen

La explosión mundial de tecnologías digitales de todas formas nos pone a la mitad de una revolución en la educación que va de la educación prescolar, primaria y media a las universidades. El uso de aprendizaje potenciado por la tecnología mantiene la enorme promesa de ser un medio eficaz e igualitario que ayude a aumentar el número de personas (jóvenes y adultos) que aprenden o aumentan el aprendizaje que les permita enfrentar retos en un mundo cambiante y competitivo. Esta transformación en cómo vemos y producimos educación se ha referido como Educación 3.0 debido a su carácter interactivo, de auto aprendizaje y personalizado. Sus características incluyen ambientes y experiencias digitales omnipresentes y adaptativas, y la habilidad de los programas de auto-aprender y ajustarse de manera precisa e individual al estudiante. Los componentes como la personalización del aprendizaje y la educación basada en competencias comparten características críticas con el análisis de la conducta. Este artículo resalta la congruencia entre la Educación 3.0 y el análisis de la conducta y la oportunidad para los analistas de la conducta de crear un cambio.

Palabras clave: Análisis de la conducta, tecnología, innovación educativa

Status of Education in the World

While the institution of public schooling seems familiar to us all, public schools did not begin appearing across the globe until the nineteenth century (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2007). Historically efforts towards educating the masses were based on religious motivations, such as Jerusalem's 63-64 C.E. decree that every Jewish community establish a school to provide religious instruction to all children or the mid 1500's goal of the Church of Scotland for a free school in every parish to provide religious education to the poor (New Word Encyclopedia, n.d.). Secular mandatory schooling laws were initially passed in Europe and the United States in the early to mid 1800's, and then spread globally throughout South America and Africa (UNESCO, 2007). Thus the structured provision of schooling to "all" is a modern development occurring within the last 200 years, or in some countries, only within last 50 years.

UNESCO (2013) reports that there are over 1.4 billion students on earth, with about 62 million educators to striving to provide them an education. All too often these needs aren't being met: more than 57 million children have no access to any kind of school (the schools simply aren't there) while an additional 250 million children have some access yet fail to achieve even basic literacy and numeracy skills. Increasing education levels, especially primary education, is the single most effective means of reducing poverty and many other world ills (Global Partnership for Education [GPE], n.d.). According to UNESCO (2011), if all children in low-income countries were taught basic reading skills, at least 171 million people could be lifted out of poverty. Even a basic education has far reaching impact (GPE, n.d.; UNESCO, 2011), including:

- Improved health: Infant mortality can be reduced by 5% to 10% by an additional year of a mother's schooling and results in healthier children. People with some schooling are better prepared to prevent disease and to use health services effectively. Young people who have completed primary education are 50% less than half as likely to contract HIV.
- Higher wages and economic growth: For many poor countries, each additional year of schooling results in 10% higher wages, and even 10%-20% for women. It can increase a country's average annual gross domestic product (GDP) by 0.37%. No country has ever achieved rapid and sustained economic growth without at least a 40% adult literacy rate.
- Democracy and political stability: Education is strongly correlated with the growth of civil society, democracy, and political stability. Increasing the enrollment rate for secondary schooling by 10% higher than the average reduces the risk of war by about 3%. Across the world, increases in education and democratic governments are highly correlated (Glaeser, Ponzetto, & Shleifer, 2007).

Innovation and Change

Nelson Mandela (2003, para 14) said, "Education is the most powerful weapon which you can use to change the world." The world is indeed changing, at an exponential pace. Within the last two centuries, most industries have seen monumental and expansive transformation, for instance we can easily see innovation and disruption in transportation (from horse drawn carriages, to the steam engine, the automobile, single engine plane, supersonic jet, and even space travel; see Herbst, 2006), communication (from the telegraph, to short-wave radio, the telephone, satellite phone, and now Internet-based smart phones and cloud-based communication; see Poe, 2013), and even surgery (with the advent of anesthesia, antiseptics, X-rays, lasers, sensors, robotics, 3d carbon printing, and the professionalization, minimization, and routinization of procedures; see Gawande, 2012).

How we use the Internet has changed dramatically in the approximately 20-25 years that most people have been aware it existed. For most of us, our introduction to the Internet came through the World Wide Web (www). The Web has gone through three major transformations since its inception (Fuchs et al., 2010; Berners-Lee, Hendler, & Lassila, 2001). The Internet before 1999 is thought of as the "Read-Only" web, or Web 1.0. Initially most use was limited to finding and reading information presented, as exemplified by the millions of static websites with no active communication or information exchange between the user and creator.

This desire to exchange information was the impetus for Web 2.0 and the birth of user-generated content. In this period of the "Read-Write" (or read-write-publish) web

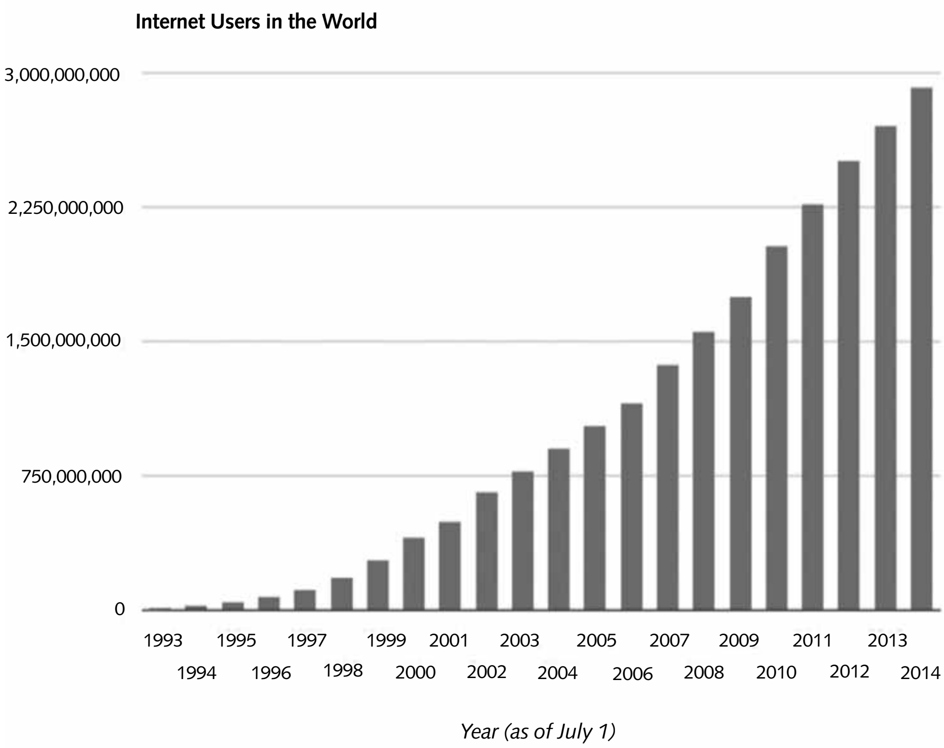

Figure 1. Worldwide Internet Users by Year. Source: Internet Live Stats, http://www.internetlivestats.com/internet-users/

people began creating and contributing information through blogs, wikis, photo or video sharing sites, and their own web pages. From 1999 to 2013, as the Internet became a two-way street (and then a multi-lane highway), the number of Internet users increased tenfold to over 3 billion (Internet Live Stats, 2014). Figure 1 displays of the worldwide total of users by year.

We now find ourselves well into Web 3.0, the "Read-Write-Execute" web (better known as the "Semantic Web"). In this case semantic refers to the ability of computers to add meaning or context to data, thus reducing the communication gap between humans and applications. Internet use is influenced by the meaningfulness of data, personalization, intelligent search, individualized targeted advertising, and how people and things are connected. In "The Internet of Things" Web 3.0 moves beyond the physical walls of the computer to connecting more and more devices (such as smartphones, cars, household appliances, personal sensors, self-driving cars) to exchange data, generate new information, and become even more efficient (Höller et al., 2014). The use of "big data" (i.e., large data sets that require supercomputers to analyze and make connections between the data), personalization (e.g., Amazon's "recommended for you" or Apple's "Genius" playlists), and algorithms that parse specific information (such as search results that are influenced by prior searches) are already prevalent as we move more solidly into the Web 3.0 and beyond (Aghaei, Nematbakhsh, & Farsani, 2012; Spivack, 2008).

Change in Education

One industry that does not seem to be experiencing such a rapid, dramatic, or fundamental shift is education. Many writers, scholars, researchers, politicians, and educators lament that education is not keeping up with our rapidly changing world (Cavanaugh, 2012; Wallis & Steptoe, 2006). The history of change in education is replete with educational "fads" or quick fixes aimed at remediating deep-seated educational problems, but rarely (if ever) making a truly meaningful change or having a lasting effect (Paul & Elder, 2007). With the waves of new laws, structures, pedagogies, assessments, techniques, and tools designed to improve learning, and with the billions of dollars spent annually on education (e.g., $810B in the U.S., $123B in the U.K., $75B in Mexico, and $62B in South Korea; see The World Factbook, 2013) we are still left with too many children not learning basic skills, boredom and frustration at school, and multitudes of students not graduating (see Noguera, 2003). Similar to the time when public schools were first mandated, most schooling takes place in "brick and mortar" buildings, with "knowledge" passed from a teacher to groups of students. It remains inaccessible to millions of people, many students who have access still struggle with learning fundamental skills, and we have a long way to go to equip all learners with 21st century skills (such as critical thinking, problem solving, creativity, innovation, communication, collaboration, visual literacy, scientific and numerical literacy, and cross-disciplinary thinking; see Bellanca & Brandt, 2010; Trilling & Fadel, 2009).

Yet perhaps things are primed for change. With the advent of new digital technologies, a growing science of teaching, learning, and behavior change, and the seemingly inescapable shifts that are occurring in the world around us, we may be at the brink of a metamorphosis in how education occurs. The example of the transformation of the web could also be used to illustrate impending transformations in teaching and learning. Lengel (2013) covered this parallel extensively, pointing out the distinctions between Education 1.0 (the agricultural age), Education 2.0 (the industrial age), and Education 3.0 (the era into which we could be moving). Table 1 presents characteristics of each of the three "stages" across features such as school location, teacher role, or desired outcomes.

Education 1.0 is similar to Web 1.0 with its a top down approach, where information is pushed out to students in a predominantly one-way process. As noted by Keats

Table 1

Characteristics of Education 1.0, 2.0, and 3.0

	Education 1.0	Education 2.0	Education 3.0
"Technology" is…	unheard of (or confiscated)	cautiously "adopted"	ubiquitous
Teaching occurs…	teacher to student	teacher & student to student	teacher & student to student & teacher
Teachers are…	trained	professionally certified	everyone
Schools are located…	schoolhouse	building & online	anywhere, everywhere
Information comes from…	Standard texts	"adopted" text & some open source	multiple sources
Outcome of learning…	grades; graduation; trade	grades; graduation; trade	academic and social competencies
Teachers role…	sage	guide/source	orchestrator, curator, & collaborator
Students role…	largely passive	emerging active; "ownership"	active; w/ownership; responsibility

Note: Adapted from Keats and Schmidt (2007), and Moravec (2008).

and Schmidt (2007), students are primarily consumers of information delivered to them, with any activities related to that information rarely (if ever) informing the original resources or what should be done in the future. Lengel (2013) notes that a surprisingly high number of classrooms and schools still operate run in the Education 1.0 model. Similar to Web 2.0, Education 2.0 features more interaction: between the teacher and student; the student and other students; and even student to content developer or expert. Increased connections within Education 2.0 are exemplified in the use of web-based technologies to support project-based learning, cooperative learning, class wikis, blogs, and social networking in the classroom (Gerstein, 2013). The practices have been adopted by many educators, but are not yet the norm. In the vein of Web 3.0, Education 3.0 focuses on personalization, individualization, and the use of data and digital tools to make education more meaningful and effective. Due to the multi-directionality of information and the plethora of content available on the web, schools are anywhere, "teachers" are anyone, and learning occurs anytime. Education 3.0 is viewed as an opportunity to reach "a potential tipping point, where major changes may happen as a result of developments in technology, social networking, deeper understanding of educational process, as well as new legal and economic frames of reference" (Keats & Schmidt, 2007, Introduction).

Even now predictions are being made regarding web 4.0 and beyond. For the web, prognostications include even greater mobility, neurotechnoloy , and a linked in web which computers communicate with us in the way we communicate with each other (including emotion) and a blurring of the lines between human and digital (Burrus, 2013). In the education domain, while the future will surely include even greater access, mobility and interconnectivity, more intelligent and predictive data systems, and a greater use of personal and environmental sensors, it could be influenced by neurotechnology as well. For example, scientists from the University of Southern California in collaboration with Wake Forest University have created a microchip system that allows memories or learned behavior to be transferred from one brain to another, as well as form brand new (non-existent) "memories". Studies with mice confirm the ability to create, record, download and transfer memories into other mice implanted with the same chip (Berger et al., 2011). It is not a far stretch to imagine how current work could be applied to education—perhaps as depicted *The Matrix* (Silver, Wachowski & Wachowski, 1999) in which programs and information are "loaded" into people's brains, resulting instant learning of information and a wide variety of tasks (Higgins, 2011). While this seems quite far-fetched and perhaps a bit bizarre, it is a useful example of the possibilities we now face.

Education 3.0

Educational systems around the world are realizing the potential of an Education 3.0 (and beyond), leveraged by technology, to increase personalization and improve outcomes. One manifestation is "Personalized Learning" which represents a movement that includes for each learner: adjusting the pace of instruction (individualization); adjusting the instructional approach (differentiation); and connecting learning to the student's interests and experiences, providing a degree of choice about what is learned, when it is learned and how it is learned (Edweek, 2014). The U.S. Department of Education (n.d.) describes a vision of personalized learning supported by increasing student competencies, including

> "[t]ransitioning away from seat time, in favor of a structure that creates flexibility, allows students to progress as they demonstrate mastery of academic content, regardless of time, place, or pace of learning. Competency-based strategies provide flexibility in the way that credit can be earned or awarded, and provide students with personalized learning opportunities…This type of learning leads to better student engagement because the content is relevant to each student and tailored to their unique needs. It also leads to better student outcomes because the pace of learning is customized to each student" (para. 1).

Personalized learning encompasses numerous components to support individualization, differentiation, and supporting each student's interests and motivation. These components may be philosophical, pedagogical, structural, or rooted in policy. Each may be implemented and evaluated individually, in combined initiatives, or an integrated whole. While a detailed description of all the components is beyond the scope of this paper, a few of them that are especially relevant to behavior analysis are described below.

Competency-based education (CBE), sometimes referred to as "proficiency-based," "performance-based," "mastery-based," or in earlier permutations "mastery learning" (Keller, 1968), is both integral to and independent of the personalized learning movement. As summarized by Twyman (2014b, p. 2), a robust CBE model includes:

- student advancement based upon demonstration of mastery, regardless of time spent in instruction or place in the academic calendar
- mastery of competencies that reflect explicit, measurable, transferable learning
- objectives that have shared relevance
- learning outcomes that emphasize competencies, including the application and
- creation of knowledge, along with the development of important skills and dispositions
- meaningful assessment, often embedded throughout teaching and learning and used to inform progress and instruction
- differentiated individual support based upon student learning needs and interests
- technology used to make efforts feasible, scalable, actionable, and transparent

The comprehensive reform of basic education in Mexico is based on a competency-based curriculum (OECD, 2013). Basic education in Mexico is composed of preprimary education, primary education, and lower-secondary education. The reform of basic education occurred in three phases starting in 2004 with the reform of the preprimary education program. The program describes a plan for focusing on educational competencies at an early age. It defines competencies as "a set of abilities, which include knowledge, attitudes, skills, and dexterities attained through the learning process and used in different situations and contexts" (Carstensen, Castillo, Gutiérrez, McGrath, & Zarzosa, 2009, p. 17). This program was followed by the lower-secondary education and the primary education reforms in 2006 and 2009 (Secretariat of Public Education, 2012). The programs that composed the reform are specified in the 2011 Study Plan for Basic Education (OECD, 2013).

All CBE programs focus on specific, clearly identified learning outcomes. One recent fundamental shift in K-12 education is the achievement of these competencies in spite of the time needed to learn them (Mendenhall, 2012). In the traditional model, time spent in learning is held constant (e.g., the 180-day school calendar or a year of Algebra I) while the outcomes varied across students (e.g., each student received a different letter grade). A true CBE model inverts the process so that all students meet the learning goals, while time to do so varies. This paradigm shift has opened the door to other schooling initiatives (see Twyman, 2014b), such as: ending the letter grades or even grade level system in favor of other means to indicate competency and progress; flexible instructional methods that support individual differences; individualized pacing based on student learning; alternative measures of learning including embedded assessment and integrated formative evaluation (see Worthen & Pace, 2014); persistence and "recycling to mastery"; and gaming mechanics (such as clear goals, levels, points, badges, schedules of reinforcement, limited holds, and behavioral momentum, see Kapp, 2012). As the terms indicate, each of these components seems to be highly congruent with behavior analysis.

The rapidly expanding world of mobile and digital technologies, coupled with the capacity and extraordinary reach of the Internet, can bring remarkable new possibilities to teaching and learning, In the U.S. Dept. of Education's 2010 white paper "Transforming American Education: Learning Powered by Technology" the following terms are used liberally throughout the publication:

"be clear about the outcomes"
"continually monitor and measure performance"
"be accountable for progress and results every step of the way"
"Assessment: Measure What Matters"
"diagnose strengths and weaknesses in the course of learning when there is still time to improve student performance"
"Use Data to Drive Continuous Improvement"
"use data to create a system of interconnected feedback for students, educators, parents, school leaders..."

Parallels with Applied Behavior Analysis

The statements above overlap considerably with official policy held by the Association for Behavior Analysis International (ABAI). In their "Statement on Students' Right to Effective Education" ABAI asserts: the educational context should include social and physical school environments that encourage and maintain academic achievement and progress; curriculum and instructional objectives should be based on empirical validation and measurable performance criteria that promote cumulative mastery; assessment and reporting methods should provide useful decision-making based on skills and knowledge; students should be supported in mastering instructional objectives at their own pace and respond rapidly and frequently during self-paced instructional sessions; and instructional methods should adjust in response to measures of individual learning and performance (ABAI, 1990; see also Barrett et al., 1991).

Behavior analysis has a long history in education focusing on individualized, adaptive instruction, mastery-based learning, high rates of meaningful responding, frequent (or continuous) measurement, and ongoing analysis to make instructional decisions in real time (Twyman, 2014a; Axelrod, 1991). In 1954 Skinner published

"The Science of Learning and the Art of Teaching" which described a technology of instruction based on the behavioral principles of small, incremental steps, simple to complex sequencing, high rates of learner interaction, reinforcement of correct responses, and individual pacing (Skinner, 1968/2003). Fred Keller's Personalized System of Instruction (PSI), initially created for college teaching, is centered around the use of meaningful units of instruction, self-pacing, and "recycling" until mastery is achieved (see Keller, 1968). And as noted over two decades ago by Bushell and Baer (1994), "close continual contract with the relevant outcome data is a fundamental, distinguishing feature of applied behavior analysis…[it] ought to be a fundamental feature of classroom teaching as well" (p. 7).

The literature on behavior analysis is replete with meta-analyses, systematic reviews, studies, replications, and empirical demonstrations of its effectiveness in classrooms. For more than 50 years, behavior analysts have been designing, developing, implementing, testing, and refining numerous procedures that have produced substantial gains for all types of learners across a wide variety of behavior and subject matter domains (Axelrod, 1991; Heward, 2008; Twyman, 2014a). Skinner and early colleagues began an instructional technology revolution featuring well-designed instruction and scientific validation aided by mechanical delivery systems, including the teaching machine and programmed instruction (Rump et al, 2007; Skinner, 1968/2003; Vargas & Vargas, 1992). Yet even with this early use of mechanical systems to assist in instruction, Skinner and other behavioral instructional designers were explicit in stating that it was the program of instruction, not the tools, that produced student learning (Skinner, 1958).

Types of Technology

Yet for many it is the tools of educational technology that makes Education 3.0 now possible. In this heyday of technology driving educational reform it is important to distinguish between at least two types of technology: that of tools and that of instruction (Layng & Twyman, 2014; Twyman, 2014a). The first one—the technology of tools (especially mobile or digital ones) is what most people think of when hearing "educational technology." This includes the Internet, hardware, software and "apps", monitors and sensors, 3D printers and peripheral devices, and other supplements to learning.

Recent headlines such as "The World Is Open: How Web Technology is Revolutionizing Education" (Bonk, 2011) or "Technology Should Revolutionize Education" (Clemens, 2013) and many others extoll the potential of innovative ed tech to transform or "disrupt" our current (ineffective or dysfunctional) educational systems. It is clear that emerging technologies are being used in classrooms worldwide (Behrens, 2013; Briggs, 2013), and classrooms are beginning to change in some areas around the globe. Some cite the demise of the static, paper-based textbooks in favor of "textbooks and courses that understand their subject matter well enough to ask appropriate questions and that can explain the answers, assess the learner's comprehension, guide them through the subject matter and accommodate their learning style dynamically" (Haley, 2013, para. 3). Others name the 24/7 availability of information. The rise of mobile devices and apps is also widely heralded as a "game changer" in education. Thornburg (2010) contends that:

> "[I]n the whole of human history, only three major technological revolutions have fundamentally resculpted education. The first two are taken for granted: the construction of a phonetic alphabet, and the propagation of the mass-produced book in the 16th century. These changes seeped into education because they were consumer-driven, and ultimately too big to ignore" (cited in Noonoo, 2013, para. 3).

Mobile device technology and its power to disrupt education puts us on the cusp of the third revolution (according to Thornburg, 2010), because it is so consumer-driven and too big to ignore. Students are already demanding the connected, "anywhere anytime" aspect that mobile devices enable in their personal lives, to that of their school lives. Regardless of the type of technology named, or how it is expected to revolutionize education, it is clear that this focus is on the technology of tools.

The second type of technology noted by Layng and Twyman (2014) is the "technology of process", also referred to as the technology of instruction and even the technology of applied behavior analysis (a la Baer, Wolf, & Risley, 1968). This is more in keeping with a traditional definition of technology as the *use and knowledge* of tools, techniques, systems or methods in order to solve a problem or serve some purpose (see Twyman, 2011). It is in the technology of the process that behavior analysis has made significant contributions, such as that of derived stimulus relations (Rehfeldt, 2011), observational methodology (Bijou, Peterson, & Ault, 1968), negative reinforcement (Iwata, 1987), and the implicit technology of generalization (Stokes, & Baer, 1977) to name a very few—or the entire body of behavioral technologies in education (see Cooper, 1982; Skinner, 1958) and all domains (Pennypacker, 1986; Skinner, 1953).

Applying the Technology of Process

Perhaps it is with an emphasis on the practices used in teaching and learning (such as instructional design, the delivery of instruction, and the contingencies that affect both) that behavior analysis could make its greatest mark in education. It is within the technology of process that we may emphasize the use of effective practices from experimental and applied sciences and a scientific process to develop instruction (see Layng, 2014, this issue, for a detailed example). Such analyses are firmly in the wheelhouse of a science of behavior, and can be implemented in at least three nonexclusive ways:

(1) Thoughtfully applying the knowledge gained from work in the experimental and applied learning sciences when designing curricula, instruction, and the learner experience Layng, Twyman, & Stikeleather, 2003);

(2) Systematically applying a scientific research and development process in the production of instructional sequences, including software applications (Layng, Stikeleather, & Twyman, 2006); and
(3) Scientifically using valid, rigorous measurement and analysis to make explicit the information about what will be the effect with learners given certain curricula (Leon et al., 2011).

Fortunately we can turn to a few models of how this is done. The behaviorally designed and developed reading programs known under the name "Headsprout" used this approach to develop products that have taught tens of thousands of children all over the world to read and comprehend text (Layng, Twyman, & Stikeleather, 2004). Doing so required a thorough concept analysis of the components of reading and in-depth analysis of empirically verified methods for teaching those or similar components to inform instructional design. Using the same iterative testing model made famous by the Wright brothers (see Shlien, 2000), Markle and colleagues (1967; 1983/1990) showed us how to apply that approach to the development of instructional programs by systematically designing, testing, refining, and retesting each instructional component to assess its contribution to building a reading repertoire (see Twyman, Layng, Stikeleather, & Hobbins, 2005). To create Headsprout *Early Reading*, developers worked with over 500 individual learners using this rigorous, control–analysis formative evaluation process to verify each instructional component. This allowed to developers to know with precision, which sequences worked across diverse learners, resulting in 90% of learners achieving the desired outcomes Layng, Twyman, & Stikeleather, 2004).

Other behavior analytic examples of the technology of the process (incorporating all three components) exist. "Deeper learning" is a desired outcome in education today, exemplified by a student's ability to master core academic content, think critically and problem solve, collaborate and be an effective communicator, and direct one's own learning (The William and Flora Hewlett Foundation, n.d.). Using the same technology of process outlined above, Robbins (2011) describes how critical thinking and problem solving can be taught. The result of these methods can be seen in a fascinating video of two elementary students solving a reasoning word problem (see http://www.peerinternational.org/taps.html). The procedures to establish some of those foundational skills, such as parsing information and understanding what is taught, are thoroughly described by Layng and colleagues in the building of Headsprout *Reading Comprehension* (Layng, Sota, & Leon, 2011; Leon, Layng, & Sota, 2011; Sota, Leon, & Layng, 2011). The technology of process also can be used on a systems-wide scale, as exemplified by Morningside Academy in Seattle WA (see Johnson & Layng, 1994).

Layng and Twyman (2014) note "recent advances in the technology of the teaching and learning process suggest we may be beginning to combine the science of learning with the art of teaching" (p. 138). When behavior analysts consider instructional design or program/product development, a few simple steps should guide the process:

- Define what we want to see (what is success?)
- Specify the repertoires required for each component (Are these do-able, observable, measurable, engineer-able?)
- Provide a "program" that works for learners
- Provide a "program" that works for teachers

The technology of process, coupled with what we know about the contingencies of behavior change (see Mechner, 2008), provide a powerful arsenal to combat many of our seemingly intractable educational ills. Adding the technology of tools, especially "3.0" tools, make this an exciting time. Tools are an enabler for behavior analysts to apply a science of behavior in productive and knowledge enhancing ways. For education, digital technology supports: effective, engaging individualized, personalized instruction, at scale; access to vetted information and resources; the ability to create relevant (highly interactive) learning opportunities; an enhanced ability to measure, evaluate, decide, & act; improved transparency and communication; and the use of data to build smarter programs.

One of the most exciting prospects for those interested in instructional design is the use of measurement, data, and analytics. With the increase in online instruction comes an increase in data that can be used to improve education and support basic research on learning and behavior change. Data-driven instruction and decision-making is not new to behavior analysis, yet the types and methods of data collection may be. Not only are accuracy, latency, or rate data are automatically and continuously collected, but may be paired with environmental variables, setting events, establishing operations and even physiological or biological makers. Current and historical sequences of instruction can be analyzed. And with "big data," multiple data sets can be integrated to find relationships (i.e., contingencies that impact learning) that may not be apparent on a smaller scale. As noted by Guthrie (2013):

> Big data in the online learning space will give institutions the predictive tools they need to improve learning outcomes for individual students. By designing a curriculum that collects data at every step of the student learning process, [schools] can address student needs with customized modules, assignments, feedback and learning trees in the curriculum that will promote better and richer learning (para. 3).

Even more, this level of data collection and analysis empowers the technology of the process, enhancing our ability to apply our knowledge from the experimental and applied learning sciences, strengthening the ability to employ a scientific research and development process and program refinement, and perhaps most importantly make information about outcomes with individual learners clear and explicit.

The fusion of behavior analysis, learning science and technology has potential for world impact, within "Education 3.0" and beyond. Independent "forces" appear to be aligning across educational policy, advances in technology tools, measurement and analysis capabilities, supported by interconnectivity. Applying the technology of process is a missing component (Layng & Twyman, 2014). Guiding this change within systems approach (see Glenn & Malott, 2006; Sandaker, 2009) is also critical for successful outcomes. Thus it is an opportune time for behavior analysis to speak up, add their expertise, and make that difference. As B. F. Skinner said, "We know how to build better schools" (1989, p. 96). These "schools" will now look very different. With others, we behavior analysts should get to the task of building them.

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