Article

Improving the reading skills of children with neurodevelopmental disabilities: Preliminary study from Botswana

Journal of Intellectual Disabilities
2022, Vol. 26(1) 149–165

DOI: 10.1177/1744629520968968
journals.sagepub.com/home/jid

Marina Mensi
Sapienza University of Rome, Italy

Roberto Baiocco
Sapienza University of Rome, Italy

Mpho Otukile-Mongwaketse
University of Botswana, Botswana

Giacomo Maria Paganotti
Botswana-University of Pennsylvania Partnership, Botswana;
University of Pennsylvania, PA, USA;
University of Botswana, Botswana

Richard Michael Kubina
The Pennsylvania State University, PA, USA

Abstract

In Botswana, Special Needs Education has been implemented for 25 years with some success but there is still a need for evidence-based methods like Frequency Building, behavioural fluency, and Precision Teaching to be used to measure and improve school performance and learning. We explored the impact of these behavioural technologies on reading performances of four children with learning disorders (ADHD, speech impairment and acquired brain disorder) in a special school in Gaborone. At the assessment, two children were unable to read letter sounds and two could not read sight words. Reading performances were measured with frequency and displayed on a standard celeration chart. During the intervention, the length of the tasks was reduced and then augmented. Findings revealed that after 3 months of intervention children significantly increased their score stimulating self-confidence and enthusiasm during activities. This work demonstrates that behavioural technologies can be applied in Africa without using expensive or time-consuming resources.

Keywords

Botswana, behavioural fluency, case study, Frequency Building, precision teaching

Corresponding author:
Marina Mensi, Department of Developmental and Social Psychology, Faculty of Medicine and Psychology, Sapienza University of Rome, via dei Marsi 78, 00185 Rome, Italy.
Email: marina.mensi@uniroma1.it

Introduction

People with disabilities, adults, and children, are a marginalized group worldwide. Most Western countries have developed policies and interventions for people with disabilities. In developing countries, many children and adults with neurodevelopmental disabilities are neglected and experience social exclusion. These facts are well documented. In the news media, a CNN documentary 'Locked Up and Forgotten' (Mackenzie, 2011) detailed widespread poverty, poor health care, and how infectious diseases (such as HIV, malaria, and meningitis) and malnutrition promote dangerous living conditions and increase the likelihood of further impairments among people with disabilities. The documentary focused on Kenya, but such conditions are prevalent in many other countries in and outside Africa. For example, the experiences of social exclusion of individuals with visual impairment has been reported in Namibia (Tobias and Mukhopadhyay, 2017), and it has also been shown that people in low-income settings are disproportionately affected by disability due to increased health risks and limited access to services in West Africa (Jolley et al., 2018) and globally (Koller et al., 2017).

The United Nations General Assembly noted that an estimated 80% of people with disabilities live in developing countries (WHO, 2015). Living conditions in Botswana, a developing country of Southern Africa, are still plagued by similar problems. The HIV rate is 20.3% in the adult population (UNAIDS, 2020) and disabled people's needs are not met by the public sector. Poor living conditions, poverty, undernourishment, lack of proper housing, unemployment, and violence also prevail. All these factors have a negative impact on learners (Pottas, 2005). The government of Botswana implemented a special education program in 1994 with the 'Revised National Policy on Education' (RNPE) (Otukile-Mongwaketse, 2011), where it recognized the need to increase participation for disadvantaged groups in basic education. Disadvantaged groups in the context of Botswana were (and still are) those with various forms of disabilities, those who live in remote areas, learners from poor socio-economic backgrounds, individuals affected by HIV/AIDS, orphans, and girls who drop out of school due to early pregnancy (Modimakwane et al., 2015). Botswana runs five types of systems to meet the education and training needs of learners who have special educational needs. The systems include stimulation centres, special schools and centres, special units attached to regular schools, resource classrooms, and inclusive arrangements within regular schools (Otukile-Mongwaketse, 2011).

Data about learning disorders are scattered. According to a local survey, in 2014 the total number of learners with disabilities in primary schools was 7,305, and they were divided into: learning disorder, 2,287 (31%); visual disability, 1,473 (20%); speech disability, 603 (8%); physical disabilities, 472 (7%); hearing disability, 596 (8%); other health related, 1,458 (20%); multiple disabilities, 416 (6%) (Modimakwane et al., 2015). The teacher to student ratio is still very low (1:40–50) and there is no differentiated curriculum or appropriate assessment for learners with special educational needs (Modimakwane et al., 2015).

In order to address the needs of disabled people in Botswana, a clear definition of what constitutes a learning disorder is needed. Learning disorder comprehends in this study both specific learning disorder and intellectual disabilities. The Diagnostic and Statistical Manual of Mental Disorders (DSM -5) describes Specific Learning Disorder (SDL) (American Psychiatric Association, 2013) as "characterized by persistent and impairing difficulties with learning foundational academic skills in reading, writing, and/or math. The individual's performance in the affected academic skills is well below average for age, or acceptable performance levels are achieved only with extraordinary effort" (American Psychiatric Association, 2013: 32). In particular, students

with learning disorder struggle to develop reading fluency, and their common core problems are the ability to read sight words (high frequencies words), decode words, and read phrases and sentences automatically and rapidly (Chard et al., 2002).

It has been shown that students enrolled in mainstream primary and secondary schools in Botswana, without mention of possible disabilities, experience several reading problems (Commeyras and Mazile, 2011; Commeyras and Ketsitlile, 2013; Ketsitlile and Commeyras, 2014; Shepherd, 2018). A literature review focusing on reading in Botswana indicates that students in primary school, especially in the first grade, seem to read words without understanding their meaning, with poor quality reading instruction or help to understand difficult words encountered during reading (Commeyras and Ketsitlile, 2013). Furthermore, there is a lack of methods for teaching reading, and teachers do not emphasize comprehension. Teachers have not been trained on how to conduct informal reading assessments that would enable them to identify individual students' abilities and needs. Another outstanding complication includes English in Botswana being a second or third language for some children. Reading in English is more difficult than learning to read in the local language, Setswana, since English and Setswana have many phonological differences (Commeyras and Ketsitlile, 2013). It should be pointed out that like other post-colonial African countries, the Botswana government continues to maintain bilingualism and multilingualism, whilst at the same time encouraging immersion into English (Shepherd, 2018). Additionally, 'Botswana is not a reading nation', and more importance is given to the oral communication, so even for teachers sometimes it is difficult to show interest in reading (Commeyras and Mazile, 2011).

In secondary schools, reading performance results are still low both in speed and comprehension. The importance of training teachers on skills and strategies to assist all students, especially for those whom English is a second or third language should be stressed (Ketsitlile and Commeyras, 2014). Overall, literature in the field leaves the impression that teaching reading in primary school classrooms require improvement and an emphasis on quality approaches as the present pilot study seeks to examine. Considering the technological development of society, reading is viewed as crucial to a person's ability to develop fully as an individual. The lack of reading skills contributes to lower performance in other subject areas, such as mathematics, science, and geography (Moeller, 2016). Moreover, if students spend too much time decoding words, they are not always able to follow the meaning of sentences in narrative and expository texts. The experience will result in frustration and may lead students to an aversion towards reading in the future (Stevens et al., 2017).

Developing reading fluency is paramount for all students but especially those with disabilities. The reading literature defines reading fluency as the accuracy, speed, and prosody of a student reading connected texts (Kuhn et al., 2010). A similar concept is behavioural fluency, first described by Starlin (1971) and later refined by others (Binder, 1996; Haughton, 1972; Johnson and Layng, 1992). Behavioural fluency refers to the combination of accuracy plus speed of responding, that enables competent individuals to function efficiently and effectively in their natural environments (Binder, 1996). When students achieve a certain frequency of accurate performance they seem to retain, maintain, and meet the real world requirements, even in the face of distraction. Another hallmark feature of behavioural fluency is the ability to combine and adapt previous learning to more complex subject matter.

Behavioural fluency has a long history and has contributed to the understanding, improvement, and practical applications of reading. Fluent readers can retain their relative rate of reading, and they will be able to apply their reading ability to novel passages and/or more complex reading

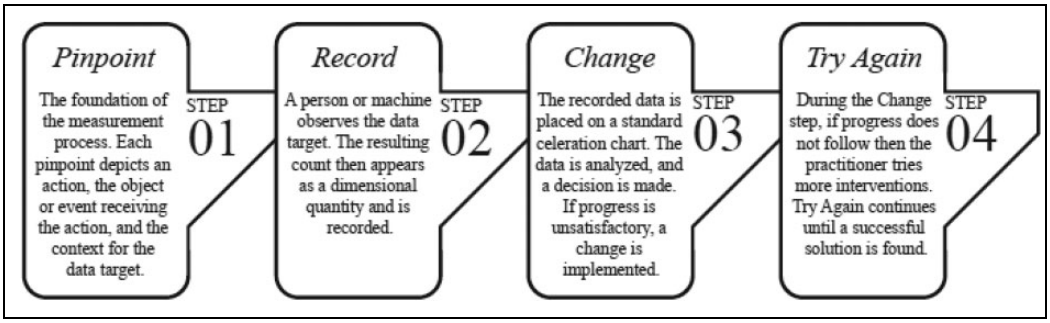

Figure 1. Four steps of precision teaching.

passages. For example, it has been demonstrated that repeated reading interventions improve reading rate, accuracy and comprehension, and that repeated reading interventions were more effective for reading comprehension (Chard et al., 2002). Furthermore, Brosnan et al. (2018) highlighted the importance of fluency in foundational reading skills for reading development. The study from Brosnan et al. (2018) and other reading research studies (Griffin and Murtagh, 2015; Kubina et al., 2008; Mannion and Griffin, 2018) provide evidence that behavioural fluency using Precision Teaching (PT) can be used to target foundational reading skills.

Precision Teaching is a behavioural technology based on positive techniques and a systematic method of evaluating instructional tactics and curricula developed by Ogden Lindsley during the late 1960s (Johnson and Street, 2012). Precision Teaching has its roots in the behavioural science, specifically in the definition of 'free-operant conditioning', a learning process through which the strength of a behaviour is modified by an event (Vargas, 2013). Precision Teaching seeks to carefully record student data and present it in a way that teachers are able to quickly ascertain if the current instruction is working or not. If not, then changes are made and systematically observed to see if they affect a student's performance and learning positively. As stated earlier, many researchers have examined academic skills through the lens of PT. The four steps of PT are shown in Figure 1.

A special intervention called Frequency Building (FB) was developed through Precision Teaching and demonstrated positive experimental results (Kubina and Yurich, 2012). FB is defined as the timed repetition of selected behaviours followed by performance feedback (Kubina, 2019). FB ends when students have reached a performance standard or fluency goal which signifies the attainment of behavioural fluency. Studies applying the FB approach to reading skills have shown substantial improvement across a range of learners with and without disabilities (Cavallini et al., 2010; Griffin and Murtagh, 2015; Hughes et al., 2007; Kostewicz et al., 2016; Kubina et al., 2008; Mannion and Griffin, 2018).

As an example, in a case study run in the UK for 10 weeks, PT and FB were applied to an intervention group where eventually the students were capable of reading four to five times more words correctly than the comparison group with endurance and stability (Hughes et al., 2007). Cavallini et al. (2010) provides another quality example using the most frequently used Italian words. Participants became proficient reading high frequency words, they also showed a significant difference between their pre- and post-test scores (Cavallini et al., 2010). Kostewicz and Kubina (2011) demonstrated that students with disabilities can improve oral reading fluency using a science textbook to practice repeated reading and retelling information. Moreover, a mixed

quantitative and qualitative study showed that PT facilitated word-identification skills. The study also emphasized the motivational characteristics of PT with the immediate positive feedback it gives to the students (Griffin and Murtagh, 2015). Furthermore, positive reinforcement added during the instruction can strengthen FB and increase the motivation to work as described in the principle of the science of behaviour (Vargas, 2013). The use of positive reinforcement can be a novel concept for some African countries, where punishment tends to be the norm in classrooms (Tilahun et al., 2016).

When PT is used in a classroom, students and teachers keep records of their academic or non-academic performances and use the record to guide their work. The records tell the students how their performance changes during time on a standard celeration chart (SCC). The visual display is a ratio chart that shows different behaviour frequencies from 1 per day to 1000 per minute. The ratio scale makes it possible to measure the rate of learning (Lindsley, 1990). The SCC differs from the more commonly used linear graph by showing how behaviours change relative to each other. Additionally, the SCC allows data to be quantified along other dimensions of change such a variability, average rates of behaviour or level, and how much improvement has occurred (Kubina, 2019).

In light of the significant hurdles faced by students with learning difficulties and disabilities in Botswana, FB, behavioural fluency, and PT offer several meaningful tools for teachers and students alike. Thus, the SCC component provides a visual display that fairly shows progress, or the lack thereof, for each individual student. Meanwhile, the FB component allows students to accelerate their growth with targeted skills and reach behavioural fluency. In combination with PT it offers a hopeful intervention for students with and without disabilities. It is the aim of the present small case study to examine how PT in combination with FB and positive reinforcement (i.e., FB reading skills, graphing data on SCC, and working towards behavioural fluency) would affect reading performances in students with disabilities in a school in Botswana.

Methods

Participants

The study took place in a private special school in Gaborone, Botswana, during 2017. The school count was approximately 35 students, but the number changed continuously due to new enrolments and dropouts. Four students from the same class were included: student A (a boy) was 6 years old with Attention Deficit Hyperactivity Disorder (ADHD); student B (a girl) was 5-year-old with learning disorder; students C and D (two girls) were 7 years old, one with speech impairment and the other one with an acquired brain disorder as a result of meningitis.

In Botswana, formal diagnosis for children with neurodevelopmental disabilities is not readily available for learners who may need it. Therefore, students for this study were selected based on paediatricians' information and school assessments. All four students were in the same class identified as 'Lower Primary', comprised of one teacher, one assistant teacher, and a total of eight students. The school benefited from a speech language therapist and a special education counsellor (the researcher) who both were able to offer individual sessions once a week for every student, as well as group sessions every day. The students involved in the study were chosen after numerous requests for help from the class teacher to the special education counsellor.

Student A had been rejected by two mainstream schools; when enrolled in the special school he was not able to read and recognize any letters or sit for more than 2 minutes at a time. He had

been diagnosed with ADHD by the paediatrician. Student B was in the special school without any diagnosis, but she showed learning difficulties. She was able to match all the 26 letters of the alphabet, but she was unable to read the letter sounds. Student C was diagnosed with speech impairment and possible learning disorders by the speech therapist. Student D had meningitis at the age of 2 years and 9 months and subsequently had a long history of seizures. Both students C and D were already able to read Consonant Vowel Consonant (CVC) words. However, both students struggled with the 45-sight words component of the Botswana Syllabus (Government of Botswana, 2002).

Formal ethical approval for the study was granted from Botswana Ministry of Basic Education [Ref: SER 1/15/2 XVI (121)]. Oral and written informed consent was obtained from the school, and all parents gave their written consent for the intervention administered to their children. Each participant was reminded that their responses would be regarded as confidential and that they could terminate their participation in all or part of the study at any time.

Setting

The sessions took place in a small, quiet office inside the special school. Each student underwent an individual session of FB and PT with a special education counsellor and a teacher assistant for 15 minutes. The students were already familiar with the location and material. Students were taken from their classes by the teacher assistant and brought to the special education counsellor's office. For student A and B, a small table and four chairs were set. There was also a pile of wooden letters cards, a digital timer set to 1 minute, and a data collection sheet where the assistant teacher registered the score for each child. For student C and D, a desk was set with the worksheets of the 45 sight words part of the Botswana Curriculum (Government of Botswana, 2002). A digital timer set to 1 minute and a data collection sheet were also present.

Teaching materials and instructions

Materials. Teaching materials for students A and B consisted of 26 wooden flashcard letters with a square-shape of 10 × 10 cm. The lower-case letters were on one side and etched with sandpaper. Students C and D read a list of 45 sight words that should have been achieved at the end of standard 1 according to the Botswana Syllabus (primary school curriculum). The words were printed on three worksheets and each one had a different words order. Figure 2 shows the list of the words from Botswana Syllabus in the English folder (Government of Botswana, 2002). Lastly, the same materials were used during baseline and condition (FB timing).

Dependent variables. Two dependent variables were used to measure reading. First, students were asked to read aloud the letter sounds (students A and B) or the sight words (students C and D) in a 1-minute timed interval. The assistant teacher recorded students' performance on a data sheet as words read correctly and incorrectly. Self-corrected letter sounds were counted as correct, but omissions, substitutions and skipping line or words were counted as incorrect. Second, the correct words or letter sounds were calculated subtracting the incorrect words/letters from the total number presented. The same procedure occurred for student C and D, namely two dependent variables were used. First, they were asked to read aloud the sight words in a 1-minute timed interval. The assistant teacher recorded sight words read correctly and incorrectly. Self-corrected sight words were counted as correct, but omissions, substitutions and skipping lines or words were counted as

I	go	come	went	up	you	day	was	look
are	the	of	we	this	dog	me	like	going
big	she	and	they	my	see	on	away	mum
it	at	play	no	yes	for	a	dad	can
he	am	all	is	cat	get	said	to	in

Figure 2. List of sight words from the Botswana syllabus (Government of Botswana, 2002).

incorrect. Second, the correct sight words were calculated subtracting the incorrect sight words from the total number presented.

Procedures

Baseline. Every student received three components of explicit instruction (Archer and Hughes, 2011). The first component was modelling and it was introduced to the student as 'my turn'; the student listened to the teacher's instruction and the teacher's modelling of reading. The second component was prompted or guided practice and presented to the student as 'our turn'; the student and teacher read together, and the teacher provided prompts and corrections if needed. The third component was unprompted or independent practice converted to a FB trial and identified by 'your turn'. During the third component, the student read aloud the words or letter sounds alone as fast as possible in 1-minute and the teacher assistant recorded the correct and incorrect words or letter sounds on the data sheet. All the students repeated the three instructional components three times, for a total of six instructional and three FB trials. The best score among the three reported trials was then transferred into the SCC. The order of the letters changed randomly and the sight words were read in different way at each component. Each worksheet presented for individual sessions also had the words in different positions.

Condition changes. In response to the students' data at baseline, condition changes were applied, in order to improve the learning outcomes. A package intervention made by PT, FB and positive reinforcement with the explicit instruction was used. In particular, letter sounds, and sight words were reduced and then increased, and a tangible reinforcer was added in the learning experience to increase the student's willingness to work. Before starting every session, students received an explanation about what would happen during the meeting and what would be expected from them. The reinforcer was used when students achieved a better score (even if marginal) on reading at

each instructional component. The researcher, in conjunction with the teacher, established the reinforcer based on what was available (toys, chocolates, candies, chips) in the special education office. If students were not able to meet the criteria for any of the instructional components, they did not receive anything and had to wait for another session.

Data and analysis

Students were monitored for the number of correct and incorrect letter sounds or sight words read per minute. The performance standard or fluency goal for the pilot study was set at reading 26 letter sounds per minute; a criterion that corresponded to the letter on wooden flashcards (students A and B). Reading 45 sight words out loud on a worksheet for 1-minute time (student C and D) was chosen as the performance standard or fluency goal.

The approach made by the intervention package used different teaching conditions developed for each individual student based on their specific needs and characteristics.

The results are displayed according to baseline and intervention conditions, each condition is separated on the SCC segment (Figure 3) by a solid line that specifies the type of intervention that has been applied. Baseline data were collected once a week for 3 weeks, for a total of three sessions, and each child completed the session in 15–20 minutes. During baseline, the same instructional episode was used for all students, no reinforcers were added nor were letter sounds or sight words changed. Due to their different school attendance rates, all students' baselines were done at different times during the school year. Each student had their own chart for a total of four SCCs on the PrecisionX app (Central Reach, 2020). A dot was used to mark the correct answers and an X to mark the incorrect answers (White and Neely, 2004).

Student A and D had one intervention condition change lasting seven sessions of 15–20 minutes each for 7 weeks for a total of 2 months corresponding to a whole school term (removing the holidays). For both students, a condition change was the introduction of FB and a reinforcer. Student A chose a toy before starting the three 1-minute FB trials by himself ('your turn') and he had permission to play with it for a minute, measured with the digital timer, if he beat his score. The researcher allowed him to choose reinforcers before starting the session because he wanted assurance he would receive something if he surpassed his score, and because he needed to be reminded that he was working for that toy. Student D also received a handful of chocolate cereals after the three 1-minute FB trials ('your turn') whenever she overcame her previous score. Student B and C had two intervention condition changes.

The first intervention condition for student B lasted for three sessions of 15–20 minutes each for 3 weeks. For student B the two conditions were: (1) decreasing the length of the task through the reduction of the number of letter sounds from 26 to 15, and (2) to allow her to play with a bead maze for 1 minute whenever she overcame her previous score. The intervention condition regime was then switched when the student reached the aim on the SCC that consisted in reading correctly all the 15 letter sounds. The second intervention condition for student B lasted for four sessions of 15–20 minutes for 4 weeks. The second condition was: increasing the number of letter sounds from 15 to 26 and allowing her to play with the bead maze game every time she overcame the previous score for the three times 1-minute reading by herself ('your turn').

For Student C the first intervention condition lasted four sessions of 15–20 minutes each for 4 weeks. The number of sight words was decreased from 45 to 20 and the intervention condition was switched when the student reached her aim. She received a jellybean as a reinforcer every time she read by herself during the three FB trials if she exceeded her previous score. The second

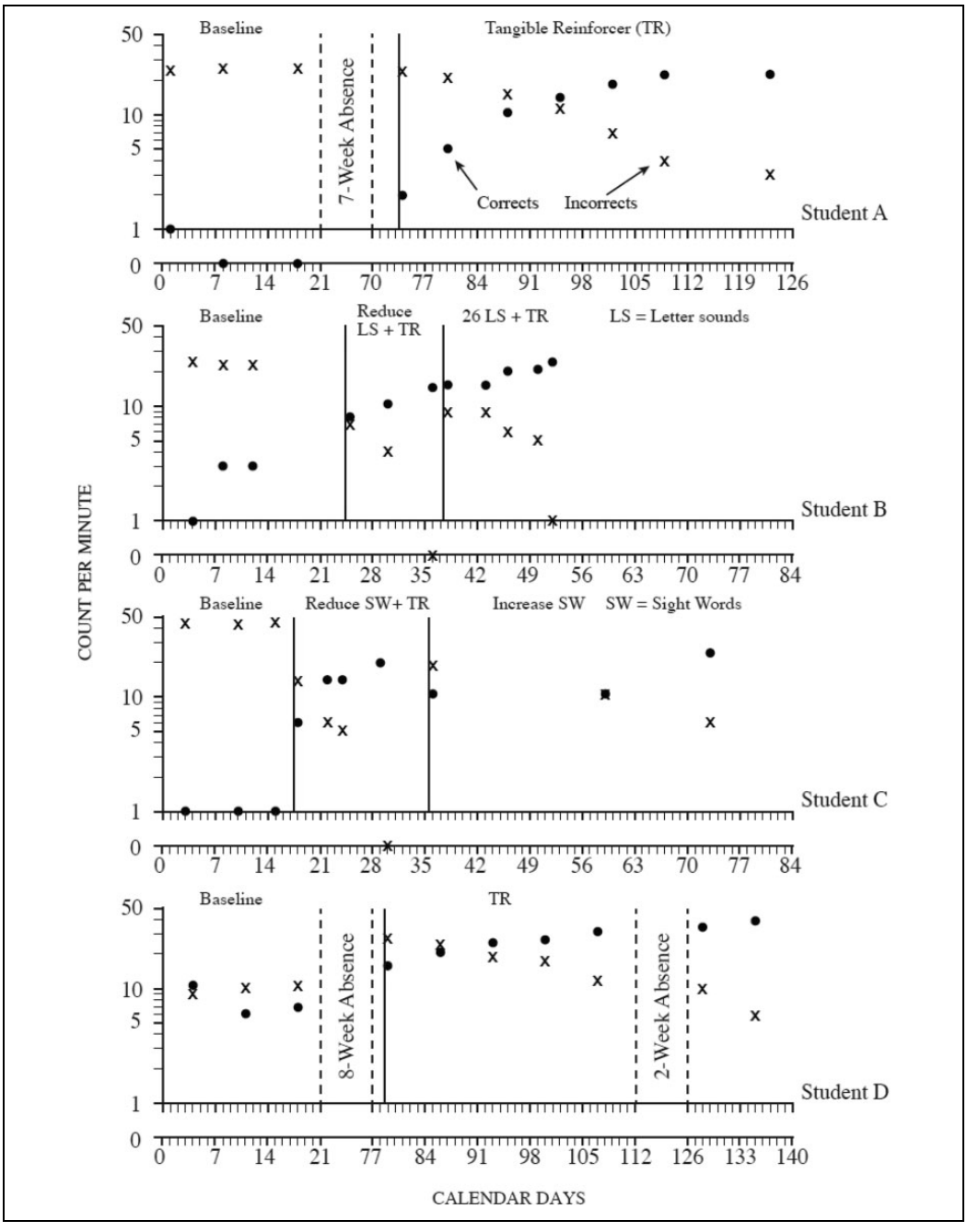

Figure 3. Standard celeration chart student A, B, C and D. On the x axe are visible the calendar days. On the y axe is visible the number of performances counted per minute.

Table 1. Growth classification based on celeration values (Kubina and Yurich, 2012).

Celeration values range	Percentage weekly growth	Growth classification
x3.0	201% + weekly growth	Super-massive growth celeration
x2.0–x3.0	101–200% weekly growth	Massive growth celeration
x1.8–x2.0	80–100% weekly growth	Exceptional growth celeration
X1.4–x1.8	41–79% weekly growth	Robust growth celeration
x1.25–x1.4	25–40% weekly growth	Acceptable growth celeration
x1.0–x1.25	0–24% weekly growth	Unacceptable growth celeration

The values range for celeration are always referred to the acceleration data.

Table 2. An index of the significance of improvement values (Kubina and Yurich, 2012).

Improvement index	Significance
x1.0	No change
x1.0–x1.2	Very slight accuracy improvement
x1.2–x1.3	Small accuracy improvement
x1.3–x1.5	Adequate accuracy improvement
x1.5–x2.0	Substantial accuracy improvement
x2.0–x3.0	Exceptional accuracy improvement
x3.0 +	Extraordinarily remarkable accuracy improvement

intervention condition lasted for three sessions of 15–20 minutes each for 3 weeks. The sight words were then increased to 45 from the baseline and the reinforcer was maintained.

All students' data were elaborated using a within condition analysis. A within condition analysis shows how behaviour changes within a condition (Kubina, 2019). The analysis measures were level, celeration, and improvement index.

Level is the average response rate of behaviour in a condition. In particular, it measures the responses for correct words and incorrect words during baseline and intervention conditions (phase of FB).

Celeration is a basic unit of behaviour change represented as count for a time unit over a time unit (count/time over time) (Kubina and Yurich, 2012). Celeration values were calculated for correct and incorrect replies during baseline and intervention conditions. A behaviour with an upward slope, acceleration, requires a times symbol (x), whereas a behaviour with downward slopes, deceleration, uses a divide symbol (÷) (Kubina and Yurich, 2012). The celeration reference values are reported in Table 1. The improvement index is a measure of the change in the accuracy of behaviour from the beginning of an intervention phase to the end and it is used to analyse concurrent celeration data (e.g., correct and incorrect performances) (Kubina, 2019). The improvement index captures the ratio of the concurrent acceleration and deceleration values for each condition (Table 2). The numerical value of the improvement index states the degree of progress across time and communicates exactly how the behaviour changes for correct and incorrect answers (Kubina and Yurich, 2012). The significance of the improvement index is shown in Table 2. In the present study the level was calculated using the geometric mean of correct answers. The PrecisionX (Central Reach, 2020) software uses linear regression with a

logarithmic transformation for celeration. The improvement index was similarly calculated by the software.

Statistical analysis. The researchers also conducted a Yates corrected chi-square test to find if the proportions of correct and incorrect responses varied between initial (baseline) and final (condition) steps of the PT procedure. Alternatively, the Fisher's exact test was performed when data outputs had a value less than five in the 2×2 table. These are standard tests that were used to further validate the results of the study. The smaller the associated P-value for the statistics, the stronger the evidence of a significant change in the rate of responses between baseline and condition results, considering a P-value less than 0.05 as statistically significant. The researchers compared baseline and condition absolute numbers of correct and incorrect responses. In the case of two conditions being applied, a comparison was made between baseline and condition 2 results. Evaluation of Yates corrected chi-square and Fisher's exact tests was performed using the Social Science Statistics software (freely available at https://www.socscistatistics.com/tests/).

Results

Level. The average correct responses during 1-minute timing for student A showed a rise from 0.71 correctly read words during baseline to 10.58 during the intervention. Also, incorrects dropped from an average of 25.49 to 9.62. Student B had 2.08 average corrects per minute during baseline that rose to 10.97 in the first condition and 19.11 in the second condition.

The drop in incorrects for student B went from 23.65 to 2.41 during the first condition, and to 4.97 during the second condition. Student C's corrects went from 1.44 to 12.60 and 15.82 from baseline to the first and the second condition, respectively. Incorrects changed from 43.32 to 3.81 and 11.96. Student D started with a level of 7.73 average corrects during baseline to 27.32 during the condition. Incorrects went from 9.97 to 14.98 during the condition. All data are shown in Table 3.

Celeration. It was observed that during the various intervention conditions students showed important learning changes. Student A's acceleration rate for correctly identified letters grew by x1.32 per week and the deceleration rate for incorrectly identified words decelerated by $\div 1.33$ per week (after seven sessions). Table 3 shows this improvement after the approach was switched from baseline to intervention condition.

In the case of student B, during the first intervention condition the acceleration rate for correctly identified words was x1.44 per week and the deceleration rate for incorrectly identified words fell sharply from $\div 1.08$ to $\div$ 4.83 per week (after three sessions). During the second intervention condition the celeration value remained relatively steady compared to the first intervention condition but it was still consistently growing with an acceleration rate of x1.26 per week and a deceleration rate of $\div 2.8$ per week (after four sessions), as shown in Table 3.

Student C showed an acceleration rate of x1.77 per week and a deceleration rate of $\div 5.36$ per week after four sessions under the first intervention condition. The respective rates of acceleration and deceleration were x1.16 per week and $\div 1.24$ per week after three sessions under the second intervention condition, as shown in Table 3. Lastly, student D showed an acceleration rate of x1.08 per week and a deceleration rate of $\div 1.16$ per week after seven sessions under the first intervention condition, as shown in Table 3. Compared to baseline, student D acceleration grew gradually, and the deceleration has an acceptable trajectory.

Table 3. Baseline and positive reinforcement condition results for student A, B, C and D.

Student		Level		Celeration		Improvement Index	Answers		Fisher exact test *P*-value
		Acceleration	Deceleration	Acceleration	Deceleration		Correct	Incorrect	
A	Baseline	0.71	25.49	÷2.19	x1.05	÷2.29	2	24	<0.00001
	Condition	10.58	9.62	x1.32	÷1.33	x1.75	22	4	
B	Baseline	2.08	23.65	x2.83	÷1.08	x3.06	3	23	<0.00001
	Condition 1	10.97	2.41	x1.44	÷4.83	x6.94	15	0	
	Condition 2	19.11	4.97	x1.26	÷2.8	x3.54	25	1	
C	Baseline	1.44	43.32	x1.13	÷1.01	x1.14	14	31	0.0029
	Condition 1	12.60	3.81	x1.77	÷5.36	x9.48	20	0	
	Condition 2	15.82	11.96	x1.16	÷1.24	x1.45	29	16	
D	Baseline	7.73	9.97	÷1.25	x1.11	÷1.39	17	28	<0.00001
	Condition	27.32	14.98	x 1.08	÷1.16	x1.26	39	6	(chi-square statistic with Yates correction = 20.8456

All the measurements were calculated using the geometric mean. The geometric mean of the set of positive numbers is the root of the product of the values (n = count of values). Level is the average response rate of behaviour in a condition. Celeration represents the rate of change during a condition. The Improvement Index is used to analyse between concurrent celeration (e.g., correct and incorrect performances).
Fisher exact test or Yates corrected chi-square used for comparison of baseline and condition (2, for children B and D) results (correct and incorrect answers).

Improvement index. Student A showed an improvement index of x1.75 (Table 3), Student B showed an improvement index of x6.94 on the first intervention and x3.54 during the second intervention condition (Table 3). Student C had an improvement index of x9.48 under the first intervention condition, while under the second intervention condition it was x1.45 (Table 3). Lastly, student D had an improvement index of x1.26.

Finally, significant *P*-values associated to the tests (Fisher's exact or Yates corrected chi-square) of the comparisons between initial (baseline) and final (condition) absolute numbers of correct and incorrect responses were found, thus confirming the efficacy of the intervention (Table 3).

Discussion

The study demonstrated that the intervention package using PT, FB and positive reinforcement with explicit instructions, improved the reading skills of four students with a range of disabilities in a special needs school in Gaborone, Botswana. Results for all students (Figure 3) showed a marked difference between baseline and intervention conditions and, according to the literature, the significance of the improvement index is considered 'extraordinarily remarkable' (Kubina and Yurich, 2012). Overall, all students reached the range of the fluency goals as shown in Figure 3 and Table 3, despite having received intervention spaced out across time. Only student C had a number of correct words slightly lower at the second condition, visible also by looking at the celeration line and improvement index on the second condition (Figure 3). Fisher exact test associated *P*-value was also less (but still highly) significant compared to the other students' outcomes (see Table 3) in line with the other indices.

Student A greatly benefited from the package intervention. The structure of the instructional episode in combination with PT and FB defined exactly teachers requests, while the positive reinforcement made him able to work more effectively. His reinforcer condition was playing freely for 1 minute with one of the toys available in the office. While he did not have a favourite toy, he was at all times under instructional control and accepted the offered reinforcer, playing with it appropriately every time he beat his score. When the timer sounded after the break, he did not need to be called but remained seated at the table ready to start the trials and saying '(. . .) and then we play again!'. Looking at his SCC segment the acceleration score for correct answers quickly grew, meaning he learned rapidly. The improvement index, x1.75, was also indicative of a substantial improvement (Kubina and Yurich, 2012).

Student B was exposed to two separate interventions still made by the intervention package but with two different conditions. The first condition consisted of reducing the letter sounds from 26 to 15. The second intervention condition began when acceleration or deceleration scores reached the pre-determined level score (15 letter sounds in 1-minute time). The application of FB, the practice through the time repetition and reducing the letter sounds' numbers to decode, gave to the student the ability to build her skills. The improvement index indicated a marked improvement (x6.94 in the first condition, x3.54 in the second condition) while acceleration and deceleration scores changed rapidly. By all accounts, Student B benefited greatly from the intervention.

Student C, like student B, showed an important improvement especially after the first intervention condition exposure. Looking at the SCC segment, reducing the number of words read incorrectly and adding a reinforcer, produced an improvement of the deceleration score for incorrect responses. The same pattern was apparent after exposure to the second intervention

condition, where acceleration scores increased, and deceleration scores decreased gradually. The improvement index was remarkable on the first condition with a x9.48 improvement and acceptable for the second condition, x1.45. Unlike the other students, students B and C were exposed to two types of intervention conditions; decreasing the length of the task seemed to be a factor in reducing the guessing of letter sounds and words, while the reinforcer was helpful in keeping motivation high. Student D scores were not as high as the previous students, but she still shows improvement with a deceleration and acceleration respectively of x1.08 and ÷1.16 and a small improvement index. Notably, students did not have the opportunity to receive daily sessions. Instead, students had a less intense presentation of one session per week. The students frequently skipped school (except student B) mostly due to financial constraints. Despite the spread of sessions across time, the consistent improvement of students' growth of corrects words per minute and subsequent reduction of incorrect words per minute highlights the power of the intervention package. Increasing the frequency of sessions each week may result in greater growth rates and accelerated learning.

The primary finding of the pilot study showcases a meaningful increase in the sight words and letter sounds following the 7-week FB and PT intervention. We emphasize the use of SCC because it was easy to read, informative, and provided real time feedback (Griffin and Murtagh, 2015). It has been considered a model to rely on by teachers and school personnel who participated or assisted the procedures. Through the intervention package, students had the chance to benefit from an evidence-based approach and an advanced measurement/decision making system. For the first time in Botswana, the results made teachers and school personnel willing to continue to apply those intervention. The results are in line with other studies in this field from Western countries (Cavallini et al., 2010; Griffin and Murtagh, 2015). Achieving the basic reading skills for the students is of paramount importance and this is truer in an African context. Letter sounds identification is the first component skill of sounding out words. Students who fluently read letter sounds may sound out words more quickly than students who could not fluently. Similarly, students who could sound out words fluently can read passages more easily (Kubina et al., 2008). Children with learning disorders in Botswana can be a marginalized group. Becoming a better student and a better reader can allow them to have a brighter future and access to work. Poverty and marginalization in sub-Saharian African countries easily result from engaging in problem behaviours (drug addition, gang activity, sexually aggressive behaviour, etc.) or being an easily victim of problem behaviours (Hensels et al., 2016; Small et al., 2019). Using an evidence-based approach with a visible structure, that gives immediate result, made students and school staff aware of the feasibility of the work. The use of a positive reinforcement was an example of adding motivation to the students without using harsh and corporal punishment, a problem already underlined in other studies in Botswana (Phaladze et al., 2018) and still present in many African countries.

Due to the characteristics of the environment, this study had some limitations. First, a lack of specialized teacher/assistant personnel was combined with a low number of sessions and reading practice during the week. Second, a delay between baseline and intervention for some of the participants may have impacted the results. Third, using an AB experimental design warrants caution when interpreting the results. A fourth limitation was that the school was private and parents were always struggling to send their children to school regularly due to financial constraints. Moreover, the school was in a continuous cycle of dropouts and new enrolments that made the work difficult. It was not possible to do a proper follow-up to check for retention, endurance, stability, and application (Hughes et al., 2007). In spite of the limitations the students involved made measurable improvements in their reading performance in only seven sessions with 15–20

minute sessions per week. The level of maintenance was high and their performance improved every week. We stress this was a pilot study that confirmed the value of explicit instruction, PT, FB, and the addition of positive reinforcement within the context of Botswana. Both PT and FB are applicable to most of the school curricula and they can be useful techniques either for special or mainstream schools in Botswana. More able students can even monitor the learning by themselves or in dyads, potentially providing a fruitful mutually supportive learning environment. The possibility of such cultural shifts, especially in government schools where classrooms are overcrowded and individual sessions are difficult to set, is tremendously exciting. Moreover, it will be of interest to explore their application together with inclusive strategies such as peer tutoring in mainstream school. The use of positive reinforcement in this pilot study was essential to achieve the results and it should become an example to follow both for special and mainstream schools.

In a country such as Botswana the implementation of PT and FB can empower the students needing special education to properly access information and promote access to education for people with disabilities also on the prevention and awareness of infectious disease, including HIV (UNAIDS, 2020). Reducing barriers (informational barriers, communication difficulties, access to education and literacy and misconceptions about the health of people with disabilities) for children with disabilities and facilitating a better coping with most of the communicable and non-communicable diseases (WHO, 2015) is potentially within reach with the judicious application of PT.

To conclude, four students with disabilities were exposed to a customized FB and reinforcement intervention combined with PT that resulted in marked improvement in reading performance in all cases. However, to fully evaluate the impact that such an approach can have, a larger sample study will be needed in Botswana.

Declaration of conflicting interests

The author(s) declared following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: The fourth author Kubina RM owns equity in Central Reach. The financial interest has been reviewed by the Pennsylvania State University's Individual Conflict of Interest Committee and is currently being managed by the University. The other authors declare they have no conflicts of interest.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Paganotti GM was supported by the Penn Center for AIDS Research (CFAR), a National Institutes of Health funded program [grant #P30AI045008]. The other authors received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Marina Mensi https://orcid.org/0000-0001-6671-2121

References

American Psychiatric Association (2013) *Diagnostic and Statistical Manual of Mental Disorders: DSM-5*. Arlington, VA: American Psychiatric Association.

Archer A and Hughes C (2011) *Explicit Instruction: Efficient and Effective Teaching*. New York, NY: Guilford Publications.

Binder C (1996) Behavioural fluency: evolution of a new paradigm. *The Behavior Analyst* 19(2): 163–197.

Brosnan J, Moeyaert M, Brooks Newsome K, et al. (2018) Multilevel analysis of multiple-baseline data evaluating precision teaching as an intervention for improving fluency in foundational reading skills for at risk readers. *Exceptionality* 26(3): 137–161.

Cavallini F, Berardo F and Perini S (2010) Mental retardation and reading rate: effects of precision teaching. *Life Span and Disability* 13(1): 87–101.

CentralReach (2020) *PrecisionX*. Available at: www.centralreach.com (accessed 18 May 2020).

Chard DJ, Vaughn S and Tyler BJ (2002) A synthesis of research on effective interventions for building reading fluency with elementary students with learning disabilities. *Journal of Learning Disabilities* 35(5): 386–406.

Commeyras M and Ketsitlile LE (2013) A review of the literature on reading in Botswana primary schools. *Africa Education Review* 10(2): 204–223.

Commeyras M and Mazile BM (2011) Exploring the culture of reading among primary school teachers in Botswana. *The Reading Teacher* 64(6): 418–428.

Government of Botswana (2002) *Lower Primary School Syllabus: Standard One to Four. Department of Curriculum and Development and Evaluation*. Gaborone: Government Printer.

Griffin CP and Murtagh L (2015) Increasing the sight vocabulary and reading fluency of children requiring reading support: the use of a precision teaching approach. *Educational Psychology in Practice* 31(2): 186–209.

Haughton EC (1972) Aims: growing and sharing. In: Jordan JB and Robbins LS (eds) *Let's Try Doing Something Else Kind of Thing*. Arlington: Council for Exceptional Children, pp.20–39.

Hensels IS, Sherr L, Skeen S, et al. (2016) Do not forget the boys – gender differences in children living in high HIV-affected communities in South Africa and Malawi in a longitudinal, community-based study. *AIDS Care* 28(S2): 100–109.

Hughes JC, Beverley M and Whitehead J (2007) Using precision teaching to increase the fluency of word reading with problem readers. *European Journal of Behavioural Analysis* 8(2): 221–228.

Johnson K and Street EM (2012) *Response to Intervention with Precision Teaching: Creating Synergy in the Classroom*. New York, NY: Guilford Press.

Johnson KR and Layng TVJ (1992) Breaking the structuralist barrier: literacy and numeracy with fluency. *American Psychologist* 47(11): 1475–1490.

Jolley E, Lynch P, Virendrakumar B, et al. (2018) Education and social inclusion of people with disabilities in five countries in West Africa: a literature review. *Disability and Rehabilitation* 40(22): 2704–2712.

Ketsitlile L and Commeyras M (2014) Reviewing published information on reading in Botswana secondary schools. *Reading & Writing* 5(1): a35.

Koller D, Pouesard M and Rummens J (2017) Defining social inclusion for children with disabilities: a critical literature review. *Children & Society* 32(1): 1–13.

Kostewicz DE and Kubina RM (2011) Building science reading fluency for students with disabilities with repeated readings to a fluency criterion. *Learning Disabilities: A Multidisciplinary Journal* 17(3): 89–104.

Kostewicz DE, Kubina RM, Selfridge KA, et al. (2016) A review of fixed fluency criteria in repeated reading studies. *Reading Improvement* 53(1): 23–41.

Kubina RM (2019) *The Precision Teaching Implementation Manual*. Pittsburgh, PA: Greatness Achieved.

Kubina RM and Yurich KL (2012) *The Precision Teaching Book*. Lemont, PA: Greatness Achieved Publishing Company.

Kubina RM, Amato J, Schwilk CL, et al. (2008) Comparing performance standards on the retention of words read correctly per minute. *Journal of Behavioural Education* 17(4): 328–338.

Kuhn MR, Schwanenflugel PJ, Meisinger EB, et al. (2010) Aligning theory and assessment of reading fluency: automaticity, prosody, and definitions of fluency. *Reading Research Quarterly* 45(2): 230–251.

Lindsley OR (1990) Precision teaching: by teachers for children. *Teaching Exceptional Children* 22(3): 10–15.

Mackenzie D (2011) *Locked Up and Forgotten*. Atlanta, GA: Turner Broadcasting Systems.

Mannion L and Griffin C (2018) Precision teaching through Irish: effects on isolated sight word reading fluency and contextualised reading fluency. *Irish Educational Studies* 37(3): 391–410.

Modimakwane DB, Thobega M and Moleele LL (2015) *Education for All 2015 National Review Report: Botswana*. Gaborone: Botswana Ministry of Education and Skills Development.

Moeller JD (2016) Using frequency building to a performance criterion with early literacy skills to affect oral reading fluency for at-risk readers in the first grade. PhD Thesis, Pennsylvania State University, PA, USA.

Otukile-Mongwaketse ME (2011) Implementing inclusive education in Botswana primary school settings: an exploration of teachers' understandings of curriculum, curriculum adaptations and learners who have learning difficulties. PhD Thesis, University of Exeter, UK.

Phaladze NA, Ngwenya BN and Gabaitiri L (2018) Orphans' perspectives on grief and loss in Botswana. *AIDS Care* 30(4): 506–510.

Pottas L (2005) Inclusive education in South Africa: the teacher of the child with a hearing loss. PhD Thesis, University of Pretoria, South Africa.

Shepherd DL (2018) Understanding language in education and grade 4 reading performance using a 'natural experiment' of Botswana and South Africa. *Assessment in Education: Principles, Policy & Practice* 25(1): 87–106.

Small LA, Parchment TM, Bahar OS, et al. (2019) South African adult caregivers as a "protective shields": serving as a buffer between stressful neighbourhood conditions and youth risk behaviors. *Community Psychology* 47(8): 1850–1864.

Starlin C (1971) Evaluating progress toward reading proficiency. In: Bateman B (ed) *Learning Disorders*. Seattle, WA: Special Child Publications, pp. 389–465.

Stevens EA, Walker MA and Vaughn S (2017) The effects of reading fluency interventions on the reading fluency and reading comprehension performance of elementary students with learning disabilities: a synthesis of the research from 2001 to 2014. *Journal of Learning Disabilities* 50(5): 576–590.

Tilahun D, Hanlon C, Abebaw F, et al. (2016) Stigma, explanatory models and unmet needs of caregivers of children with developmental disorders in a low-income African country: a cross-sectional facility-based survey. *BMC Health Services Research* 16: 152.

Tobias EI and Mukhopadhyay S (2017) Disability and social exclusion: experiences of individuals with visual impairments in the Oshikoto and Oshana regions of Namibia. *Psychology and Developing Societies* 29(1): 22–43.

UNAIDS (2020) HIV and AIDS estimates, country factsheets Botswana. Available at www.unaids.org/en/regionscountries/countries/botswana (accessed 20 May 2020).

Vargas J (2013) *Behaviour Analysis for Effective Teaching*. London: Routledge.

White OR and Neely N (2004) *The Chart Book. An Overview of Standard Celeration Chart Conventions and Practices*. Kansas City, MO: Behavior Research Company.

WHO (2015) WHO global disability action plan 2014–2021: better health for all people with disability. Available at: www.who.int/disabilities/actionplan/en/ (accessed 15 March 2019).