Effects of the ABRACADABRA Software on the Learning of Kenyan Grade/Standard 3 Elementary Students: A Report on the 2016 Study[1]

Summary: In 2016, 1150 students and 27 teachers participated in this literacy study. This is an important and different study because it focuses on students in standard 3 so that even though ABRACADABRA (ABRA) software was not especially designed for older students, it worked for them. Specifically, our findings revealed that ABRA continued to produce positive effects on students' reading skills mostly benefiting their reading comprehension. Improvements were particularly important for the new students whereas those with more years of exposure to ABRA maintained their advanced position. Once again ABRA proved its potential for low readers, those in the greatest need of reading instruction. They gained from ABRA significantly more than low reading students exposed to the traditional literacy classes with a focus on teacher-directed and recitation instruction. In line with the findings of the 2015 study, use of ABRA is equally effective for the students of both genders. Boys and girls in ABRA classes showed enhanced performance on the GRADE compared to students learning to read in the traditional manner. In addition, ABRA students outperformed their peers in control classes on the end-of-year subject exams including English, Mathematics, Science and Social Studies.

[1] This research was made possible by a grant to the authors from the *SESEA project*, *Aga Khan Foundation Canada and Global Affairs Canada*

Study Sample

In 2016 grade/standard 3 students and their teachers participated in the study. The experimental group included 16 classes where about 700 students were exposed to ABRA. The control group consisted of 11 classes with about 450 students where teachers relied on their usual literacy instruction. The pre- and post-test data collection yielded GRADE (Group Reading Assessment and Diagnostic Evaluation standardized test) scores from 1,224 students from whom 1,015 completed both tests (N_{EG} = 496; N_{CG} = 517). In this sample, gender split was as follows: 471 students were male and 544 were female. It is important to note that age-wise this sample of grade 3 students was far from being homogeneous and included students from 9 years old (majority of schools) to 13 (Makupa elementary) and 15 years (Tom Mboya elementary). By the beginning of the 2016 study ten of sixteen ABRA classes had some exposure to ABRA programme in the past years; yet we were able to retrace longitudinal data for 205 students from these classes. Although Kenya end-of-the-year exam scores (English, Mathematics, Social Sciences, Science) of 1,038 students were provided for the analysis, the GRADE and exam results were available for 904 students.

Basic analysis of the GRADE missing data ($N_{Emissing}$ = 102; $N_{Cmissing}$ = 55) indicated the average pretest GRADE scores of the 55 control students who missed the post-test were significantly lower ($p<.000$) than those of the control group who completed both pre- and post-tests (N=517). Conversely, in the ABRA group the GRADE pre-test mean scores of 102 students who missed the post-test did not differ from those 496 students who completed both.

Results

Student Achievement

Similar to previous years, we compared the ABRA (N=498) and control (N=517) groups at the pretest. The result show that at the baseline the reading skills of 1,015 grade 3 students in both conditions differed significantly on all GRADE subscales. Namely, group difference stats were as follows: Vocabulary -- $F(1, 1013) = 60.37$, $p<.000$; Reading Comprehension -- $F(1, 1013) = 32.546$, $p<.000$; Total Test -- $F(1, 1013) = 52.769$, $p<.000$ and Listening Comprehension -- $F(1, 1013) = 11.527$, $p=.001$. This finding of non-equivalence between the experimental and control students' reading skills at the onset of the study came as no surprise because almost 40% of students in the experimental group had been exposed to some ABRA in previous years. Indeed, this peculiarity about the 2016 sample dictated the choice of further analytical strategies.

The distinction between new (N=293) and previous users of ABRA (N=205) in the experimental group and the pretest non-equivalence between them as well as the control students on a number of reading-related scales of GRADE standardized test made us choose repeated measures multivariate analysis of variance (RM MANOVA) for the main analysis. This analytical approach allows for answering the following research question: **Does using ABRA have effects on the change of grade 3 students' (both new and previous users) reading scores from pre- to post-test**? In other words, do both the ABRA group and the control group differ in terms

of their mean change of GRADE reading scores? Also, do students with previous exposure to ABRA maintain the level of their reading skills?
RM MANOVA results show statistically significant difference between the groups (two ABRA groups and the control group) on a combined set of reading-related skills overtime -- F(3, 1010)=2.67, p=.014. Univariate tests further indicate that it was the students' Reading Comprehension where ABRA effect was significant (F(2, 1012)=4.71, p=.009). The descriptive statistics for GRADE subtests by the three groups summarized in table 1 point out that the significant benefits of ABRA on reading comprehension were for the new users of ABRA who were exposed to the software for one year. Meanwhile the three groups' gains from pre- to post-test were comparable on the subtests of Vocabulary and Listening Comprehension where no significant difference was found. Group difference statistics was respectively F(2, 1012)=1.97, p=.14 and F(2, 1012)=1.35, p=.26.

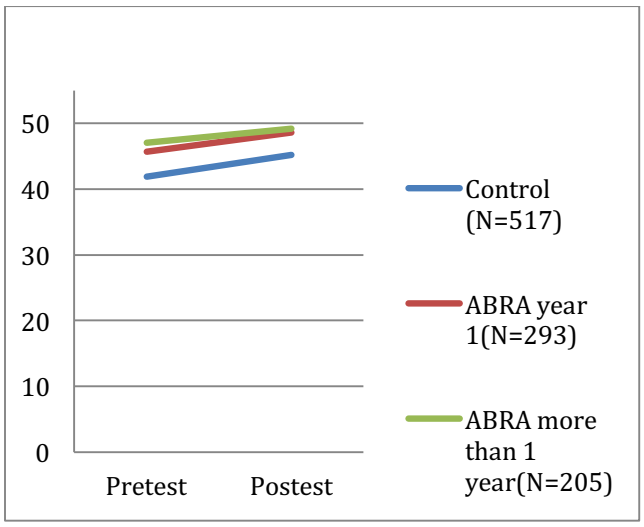
Table 1. Means and standard deviations: GRADE subtest scores by group

GRADE subtests	ABRA year 1 (N= 293)			Prior ABRA (N=205)			Control group (N=517)		
	Post	**Pre**	**Gain**	**Post**	**Pre**	**Gain**	**Post**	**Pre**	**Gain**
Vocabulary Composite	48.54	45.71	2.83***	49.2	46.95	2.25***	45.18	41.86	3.32***
Standard Deviation	*5.53*	*7.60*		*6.07*	*7.52*		*8.57*	*10.12*	
Reading Comprehension	24.86	22.79	2.07***	25.58	25.1	0.48	20.84	20.46	0.4
Standard Deviation	*8.52*	*8.36*		*8.76*	*8.75*		*9.93*	*9.77*	
Listening Comprehension	10.45	10.52	-0.07	11.06	11.62	-0.56	9.95	10.31	-0.36
Standard Deviation	*2.72*	*2.79*		*2.75*	*2.64*		*3.42*	*3.36*	

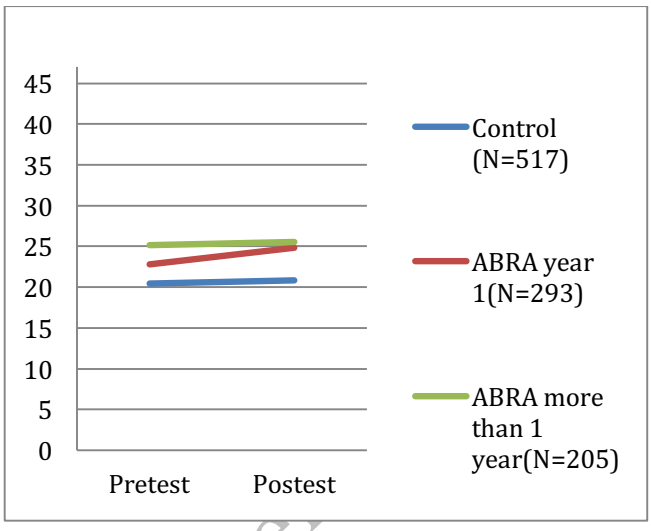
*** $p < .000$

The three groups' statistics in table 1 as well as in graphs 1-3 below suggest that grade 3 students with prior exposure to ABRA continue to maintain their superiority over the other two groups. New ABRA students demonstrated the most consistent pattern of improvement in the key reading skills. Especially important are the gains of this group in GRADE Reading Comprehension. The differences in Listening Comprehension and Vocabulary scores between groups remain in place.

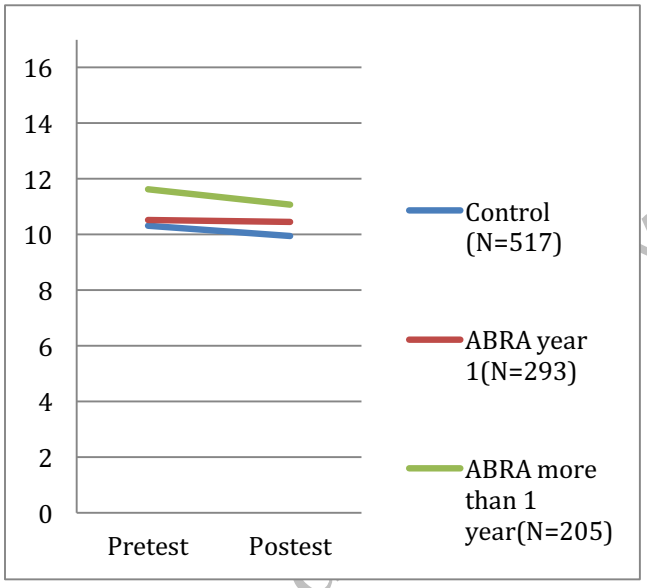
We ruled out a possibility of a GRADE Vocabulary and Listening Comprehension subscales ceiling effect (undermining this subtest sensitivity to capture change) for students with prior exposure to ABRA as it was between 3% and 2% of students who attained the maximum score of 55 (Vocabulary) or 17 (Listening Comprehension) either at the pre- or the post-test. No gains in Listening Comprehension is the finding that goes at odds with the previous ABRA research in Kenya where ABRA students' improvements were consistently and significantly higher their peers from the control group. This result may be explained by the fact that what was taught in grade 3 differs in important ways from grades 1 and 2, therefore using ABRA added nothing new in regards to developing the listening comprehension skills of grade 3 students.



Graph1. Vocabulary (max. 55)



Graph 2. Reading Comprehension (max. 46)



Graph.3 Listening Comprehension (max. 17)

Low Readers

Previous studies indicate that ABRA effects also may vary as a function of student reading ability. For instance, Abrami et al. (2014) showed that ABRA holds promise for diminishing the difference between high and low readers. Therefore, another research question we addressed was: **<u>What are the benefits of using ABRA for low reading grade 3 students?</u>** We selected 33% of students who scored the lowest at GRADE Total Test, i.e. those who obtained the score of 56 and less of 102 points. As before, we used RM MANOVA to compare the change in GRADE reading scores of low reading students in ABRA (N_E=100) and control (N_c=216) groups. It is important to note that 36 low reading ABRA students had some exposure to the software in prior years. The results reveal statistically

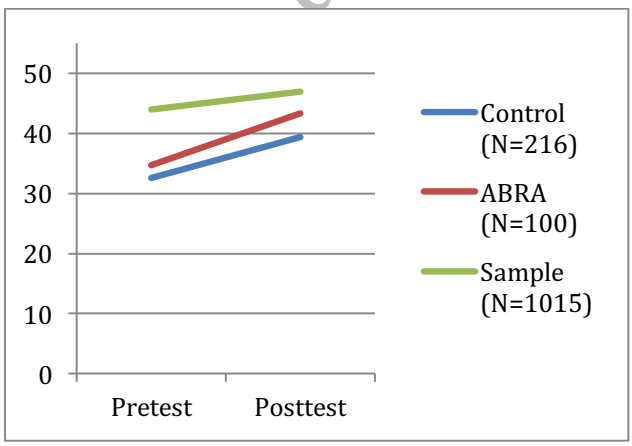
significant difference between low readers from ABRA and control groups on a set of reading-associated measures overtime -- F(3, 312)=6.24, p=.000. Although univariate tests indicate that groups differ on Listening Comprehension and Vocabulary (respectively F(1, 314)=3.27, p=.07 and F(1, 314)=3.2, p=.08), this difference reaches the threshold of statistical significance for Reading Comprehension subscale only (F(1, 314)=16.39, p=.000). Table 2 summarizes the descriptive statistics suggesting that the low reading students in ABRA classes consistently demonstrated higher gains than low readers from the control group.

Table 2. Means and standard deviations: GRADE subtest scores for low readers by group

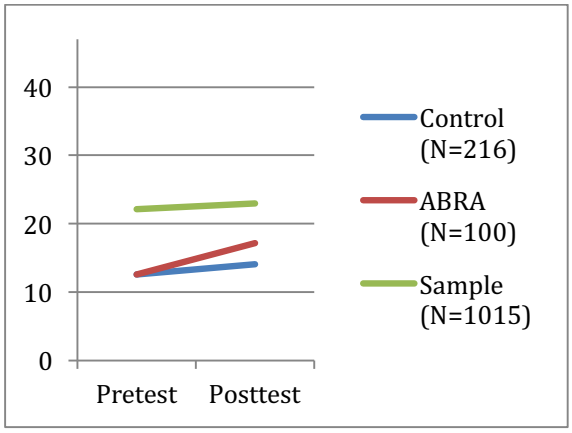
GRADE subtests	Control group (N=216)			ABRA group (N=100)		
	Post	**Pre**	**Gain**	**Post**	**Pre**	**Gain**
Vocabulary	39.41	32.53	6.88***	43.34	34.75	8.59***
Standard deviation	*9.567*	*7.864*		*6.855*	*7.089*	
Reading Comprehension	14.05	12.59	1.46	17.11	12.6	4.51***
Standard deviation	*5.052*	*3.562*		*6.648*	*3.25*	
Listening Comprehension	7.84	8.17	-0.33	9.2	8.68	0.64
Standard deviation	*2.969*	*2.846*		*2.814*	*2.856*	

*** p < .000

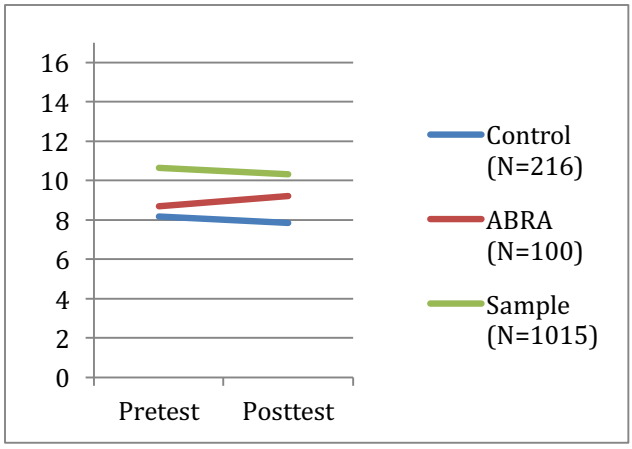
The graphs (4-6) below visually represent the difference in mean change scores of low reading students in ABRA and control group as measured by three GRADE subtests including Listening Comprehension, Vocabulary, and Reading Comprehension. Despite a considerable growth ABRA low reading students' reading-related skills including vocabulary, reading and listening comprehension, they are yet lagging behind the scores of an average grade-three student from the total sample of 1,015.



Graph 4. Vocabulary (max.55)



Graph 5. Reading Comprehension (max.46)



Graph.6 Listening comprehension (max.17)

Gender

To answer the question: **Do ABRA effects vary over time as a factor of student gender**? we added gender to the RM MANOVA full factorial model for two groups (ABRA and control). The analysis shows no statistically significant difference between gains of boys and girls from the whole sample $F(3, 1009)=2.487$, $p=.059$ as well as in ABRA and control conditions $F(3, 1009)= .825$, $p=.480$ on GRADE subtests.

Table 3. Means and standard deviations: GRADE subtest scores by group and gender

GRADE subtests	ABRA boys (N=198)			Control boys (N=273)			ABRA girls (N=300)			Control girls(N=244)		
	Post	Pre	Gain	Post	Pre	Gain	Post	Pre	Gain	Post	Pre	Gain
Vocabulary	48.42	46.19	2.23**	44.73	41.82	2.91**	49.07	46.27	2.8**	45.67	41.91	3.76***
Standard deviation	*6.79*	*8.25*		*9.35*	*10.49*		*4.97*	*7.12*		*7.61*	*9.72*	
Reading Comprehension	24.84	22.68	2.16**	21.12	20.61	0.51	25.37	24.47	0.9	20.53	20.29	0.24
Standard deviation	*9.37*	*9.51*		*10.10*	*10.26*		*8.10*	*7.86*		*9.74*	*9.21*	
Listening Comprehension	10.99	10.97	0.02	10.14	10.57	-0.43	10.51	10.97	-0.46	9.73	10.02	-0.29
Standard deviation	*2.80*	*2.84*		*3.59*	*3.33*		*2.70*	*2.75*		*3.22*	*3.38*	

*** p < .000; ** p < .00

Descriptive statistics in table 3 echoes those summarized in table 1 in that independent of gender, ABRA students outperformed control students.

Kenya Exam Scores

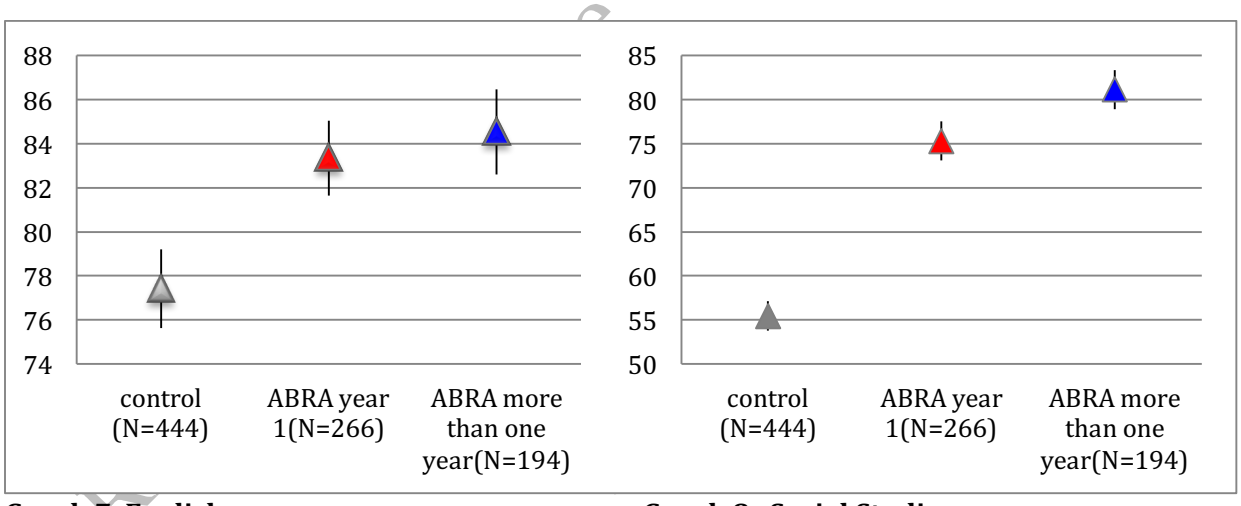
End-of-the-2016-year exam scores (English, Math, Social Science and Science) for 1,038 grade 3 students were provided by the participating schools. We were able to match them with 904 students who completed both GRADE tests (($N_E = 460$; $N_C = 444$). As mentioned earlier in this text, there was an important pretest difference between new ABRA students, students with prior ABRA experience and control students on GRADE test. Therefore, we

compared the three groups on their end-of-year exams in four key subject matters. ANOVA statistics summarized in table 4 suggest significant and important difference between the groups favouring all experimental students having either one or more years of exposure to ABRA on Kenya core exams. As expected, the highest scores on the four exams were achieved by the students with prior ABRA experience.

Table 4. ANOVA statistics for the core exams

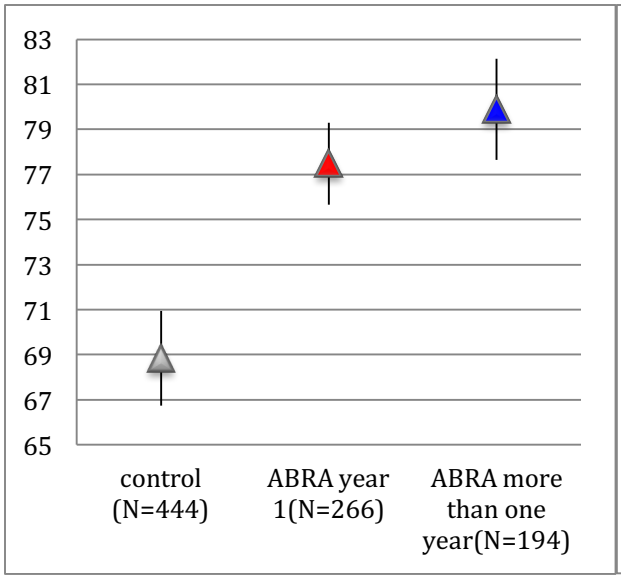
Core exams	ABRA new (N= 266)	ABRA prior (N=194)	Control group (N=444)	Group difference (F significance)
English	83.34	84.34	77.43	17.05***
Standard Deviation	*13.99*	*13.59*	*19.14*	
Social Studies	75.30	81.13	55.45	191.27***
Standard Deviation	*18.15*	*15.50*	*17.79*	
Science	77.47	79.90	68.84	29.36***
Standard Deviation	*15.13*	*15.58*	*22.48*	
Mathematics	*70.93*	*77.67*	*61.33*	45.78***
Standard Deviation	*18.73*	*16.68*	*23.64*	

Graphs 7-10 offer representation of the three groups' scores by core exams. To add precision to the estimate of the mean scores for the three groups, we have included 95% confidence intervals to the graphs (one can be 95% confident that the population mean is within your confidence interval).

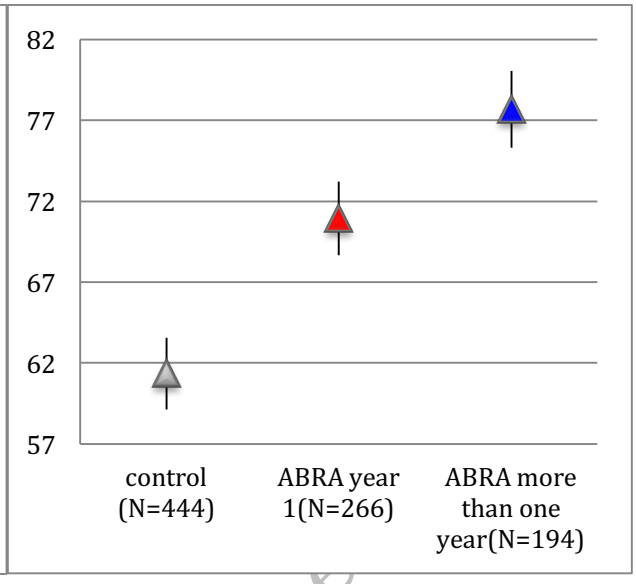


Graph 7. English

Graph 8. Social Studies



Graph 9. Science



Graph 10. Math

It is important to note that GRADE test scores (both pre- and post-) are positively and significantly correlated with the Kenya core exams suggesting convergence between the standardized test of reading ability and local measures of student achievement.

Summary of the correlation coefficients for the three GRADE subtests and Total test (post-test scores) and the four exams are presented below in table 5. The GRADE post-test scores (Total Test) were strongly correlated with the English exam scores, whereas moderately correlated with the other three exams.

Table 5. Correlation coefficients (Pearson r) between GRADE post-test scores and end-of the year exams for the total sample (N=904)

	English	Math	Science	Social science
Listening Comprehension	.479**	.365**	.473**	.280**
Vocabulary	.669**	.470**	.552**	.468**
Reading Comprehension	.610**	.538**	.664**	.519**
Total Test	**.702****	**.566****	**.685****	**.552****

** Correlation is significant at the 0.01 level (2-tailed)

Teachers: Implementation of ABRA

Unlike previous years, this year the research team was able to collect the most complete set of the teacher- and instruction-related information. The data came from multiple participants involved in the ABRA implementation, and included ABRA Ambassadors' reports, project coordinators' reports, ABRA use trace data generated by the software (12 ABRA classes), classroom observations (14 ABRA and 11 control classes), and teachers' self-reports on their literacy instruction (*Literacy Instruction Questionnaire*, LIQ). The latter was completed as a pre- and post-test by the ABRA teachers (N=14 includes 3 teachers replacing the retired teachers) and their control counterparts (N=8). However, the full information is not available for the total of 27 classrooms (16 ABRA and 11 control).

Reports submitted by the ABRA Ambassadors (5) and project coordinator offered summary accounts of their visits to the ABRA classrooms and the regular planning meetings with the ABRA teachers. One overarching commentary percolated from these reports -- in most schools the students' exposure to ABRA was significantly less that the mandatory 2 hours per week. They explained it mainly by technology failure including electricity blackouts, server problems, non-functioning computers, broken earphones, etc. Limited access to the school computer lab or no access at all were also named among the impediments to implementation. According to these reports, in at least five classes teachers used the few available to them laptops in order to make up for their lack of access to the lab. Therefore, the minimal ratio of students per computer varied to range from 3 to 1 in the lab setting (on average about 14 desktop computers) and 9 to 1 when only the laptops were used. Persistent problems with one of the school servers hosting the ABRA installation in term 3, resulted in teachers from this school using the digital story repository, READS (stored on Concordia's server) instead. Unfortunately, we did not learn much about the pedagogical challenges that teachers faced in their literacy instruction from the reports.

ABRA use reports compiled on the basis of the trace data generated by the ABRA software were hoped to provide an objective estimate of how ABRA was used to teach literacy skills. We believe that the time students were exposed to the software generally, as well as to each of the four broad skills areas (alphabetics, fluency, vocabulary, comprehension and writing) provides some indication of ABRA implementation. These reports were available for 12 ABRA classrooms who were not systematically affected by server issues. Even so, the data from three classrooms suggested the issue with a server clock due to a low battery (wrong time stamp) making it impossible to retrieve the relevant data on use of ABRA. The maximum average estimate of ABRA use over 36 weeks of the school year is about 300 minutes per student. This is considerably lower than required by the effective implementation (60+ minutes per week) but fits the perceptions of use reported by the ambassadors and project coordinator. The fact that Term 3 was shortened might have had some impact as well. Despite the issues with the ABRA trace data, the estimates of use suggest some important patterns. Specifically, in Terms 1 and 2 the use of fluency activities dominated over the other three skill categories (i.e., alphabetics, comprehension, and writing), except in Term 3 where students spent a bit more time on writing and comprehension activities.

Classroom observations were taken in 14 ABRA classes and 11 control classes. Experimental classes were observed twice (Terms 1 and 2) whereas control classes were observed once in Term 1. The observation form is a CSLP-developed instrument. It focuses on English language activities such as word-level and text-level writing and extension activities and elicits specific information about the type of activity (e.g. segmenting, vocabulary development etc.), time spent on each activity, and technology used as part of activity instruction. The form also includes questions about student engagement with ABRA and gender-sensitive instruction and includes a five-point scale to evaluate the overall classroom instruction. Observers can also provide commentary on their impressions of the lesson.

Here we will summarize the tendencies surfacing from the forms completed in 14 ABRA classes. The observations show that the teachers' choice of stories and activities varied a little. It is not clear whether they relied on the same lesson plan developed during their ABRA meetings. Decoding, blending and segmenting are the word-level activities that the students completed on the basis of the following three stories *Waterfall*, *The Little Red Hen* and *The Dove and the Ant* on average spending about 10 minutes of class time. There was more variation in the text level activities where fluency activities, such as individual student reading to the teacher, choral reading, group reading, and tracking dominated. There was also some variety in the comprehension activities the students were completing; these included vocabulary development, story elements and summarizing. In addition, to the above mentioned ABRA books, the teachers used also *The Frog and the Well* and *Three Billy Goats Gruff*. The teachers also offered a few activities they constructed around ABRA stories and some of them related to the development of literacy skills such as retelling the story and constructing sentences with the new vocabulary, whereas other activities such as drawing and colouring did not. As expected, some group work was part of the ABRA instruction. Unfortunately, no details about how this group work was structured were provided. In the observed ABRA classes, students' engagement with ABRA was marked as quite high. This included students' enthusiasm about completing the ABRA activities, their capacity to effectively navigate the software and attend to the task when doing an ABRA activity, as well as being autonomous with little or no prompting from their teacher. The observer was not able to distinguish instruction in regard to the gender-sensitivity, such as asking questions, calling upon students, dividing in groups as well as in rating his/her impressions about male and female students, as well as in her overall evaluation of the classroom instruction. The observations taken in the same class in term 1 and 2 in time did not reveal changes in the quality of reading instruction overtime either.

The *Literacy Instruction Questionnaire* (LIQ) was used to elicit self-reports about teachers' (ABRA and control) perceptions of their literacy instruction. This is a CSLP-developed instrument that elicits teacher reports on aspects of the instructional methods they used in their classroom over the past semester including approaches in reading instruction and use of technology. Questions about activities students engage in to develop their reading and comprehension skills were based on the National reading panel report (2000) and focused on phonemic awareness, phonics, oral reading fluency, vocabulary, comprehension and writing. To capture the possible changes in the literacy instruction, the teachers in both conditions were asked to complete the questionnaire at the pre- and post-test. Twenty-two

teachers (N_{ABRA}=14; $N_{control}$=8) filled it out at the pre- and post-test. Among them there were three new ABRA teachers replacing their retired colleagues who each completed LIQ at the post-test. These were matched with those completed at the pre-test. The self-reports of the ABRA and control teachers differed neither at pre- nor at the post-test (p>. 06) and this is both with the three cases either included or removed from the analysis. On average, the teachers in both conditions reported to have their students occasionally exposed to a variety of reading activities whereas frequent engagement was reported for fluency activities only.

Conclusions

This is an important and different study because it focuses on students in standard 3. Even though ABRACADABRA (ABRA) software was not especially designed for older students, it continued to produce positive effects on students' reading skills mostly benefiting their reading comprehension. Improvements were particularly important for the new students whereas those with more years of exposure maintained their top position. Low readers, those in the greatest need of reading instruction, gained from ABRA and significantly more than low reading students exposed to the traditional literacy instruction. In line with 2015 findings, ABRA is about equally effective for the students of both genders. Both genders in the ABRA classes showed enhanced performance on the GRADE compared to students learning to read in the traditional manner, with a focus on teacher-directed and recitation instruction. In addition, ABRA had positive impacts in several school subject areas. ABRA students outperformed their peers in control classes on the end-of-year subject exams including English, Mathematics, Science and Social Studies.

These results contributed to the ABRA evidence base showing that the research-based and research-proven design of ABRA coupled with its implementation in the authentic context of Kenyan schools produce positive effects on standard 3 students' reading comprehension skills. Since ABRA is not intended to supplement classroom instruction, but to be integrated into classroom instruction, we have introduced some improvements to support the fidelity of implementation in 2016. First, we expanded and improved our teacher professional development resources and assembled them together in *The Learning Toolkit Teachers Guide: Kenya Edition.* Second, to enhance further student fluency and comprehension skills, we developed READS, a freely available digital repository of hundreds of books and stories in multiple languages including English and Kiswahili. READS fits easily on a USB key and means no Kenyan child will lack engaging reading material to practice and hone their literacy skills. Third, we more completely mapped ABRA activities and stories onto the Kenyan curriculum so that teachers will find integrating ABRA into their lessons less challenging. Fourth, we tackled the challenge of large class sizes and the reliance on frontal teaching by emphasizing cooperative small group techniques during ABRA lessons. Finally, to complement gender-balanced stories and activities in ABRA, we offered support materials to teachers to help them adequately cultivate gender equality in their classrooms.

Although we drew on multiple sources, the information about ABRA use in grade 3 classrooms was not systematic enough to judge to fidelity of implementation (FOI). In order for us to build a more comprehensive picture of ABRA implementation and to link it to students' reading gains, a few issues need to be addressed.

First, the instruments used to measure the ABRA implementation require some revision to improve their fit with the Kenya educational context and therefore improve their sensitivity to differences between Kenyan classrooms, as well as teachers' individual teaching practices. We recognize that the LIQ may be biased since questions are based on an unwarranted assumption that teachers understand the pedagogical vocabulary or techniques to teach reading or that the observer of classroom instruction can distinguish gender sensitive language. In this regard, we need to conduct an unbiased check of whether vocabulary used in the instruments makes sense to the respondents or observers and adjust accordingly. We would also need to find a way to address the potential presence of "courtesy bias" in the data, where strong cultural norms may cause the participants to provide responses that s/he thinks the researchers want to hear.

Second, technology-based educational innovations require functioning and reliable hardware. Although the researchers had previously supported schools in this effort, external support is not sustainable and schools need to take on this responsibility if they are going to embrace change. Kenya's Digital Literacy Programme that resulted in the deployment of 1,200,000 tablets in primary schools, will also have a substantial impact on improving access to ICT.

Future professional development should continue to target the importance of using a balanced approach when teaching literacy—to ensure developing skills in all four core areas. By design, ABRA allows students to explore their reading interests by developing a large repertoire of strategies (ranging from code-emphasis to literature-rich) that can be readily accessed. The software also enables teachers to make decisions on the order in which the ABRA activities are delivered, in order to meet both his/her specific curricular needs and his/her students' individual differences. In addition, assessment reports on a student's or class' performance in a particular activity may be generated to help the teacher reflect on areas of instructional need. Thus, professional development efforts can also emphasize the benefits of using ABRA's flexibility to encourage differentiated and developmentally appropriate literacy instruction. Our finding about ABRA's potential to help low reading students is of particular importance as problematic reading skills and subskills of an individual student or groups of students can be effectively targeted by the software thus reducing the gap between the low and more able readers.

Educational change takes time. Given the impending competency-based curricular reforms in Kenya, many changes in teaching practice are imminent. With teachers at the centre of any effort to produce positive change in student learning, the professional development aspect of an intervention is critical to its successful adoption and integration into teaching. For ABRA to produce optimal results, training efforts need to be responsive and relevant such that teachers can fully embrace the pedagogical sophistication offered by ABRA. Such is needed in order to move away from using drill and recitation methods of teaching, towards using a more learner-centred approach where ABRA is embedded within literacy instruction, not simply added on during a 30-minute lab session.

Thus, our focus throughout 2017 continues to be on learning how best to support teachers in their use of the software. At the same time, we are learning how to maintain the implementation over a period of time, and how to scale up or expand effective uses of ABRA to a larger number of sites and contexts in Kenya. After all, successful adoption of an educational innovation implies its effective and sustained use over time and its expansion across a country.

For further information about our project, please visit www.concordia.ca/ltk/international or contact:

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