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

Summary: This pilot study explored the feasibility of implementing ELM in Kenyan math classrooms. The results were obtained using a standardized test of mathematics achievement and demonstrated that this measure possesses a sufficient degree of sensitivity to capture the change in mathematic skills for kindergarten and grade-one students between pre- and post-test. It is important to note that as a result of instruction where ELM was integrated, a) the initial pre-test gap between low and high performing students started closing for the subtest measuring language, vocabulary and representations of mathematics; b) students of both genders gained nearly equally. Yet, in the absence of a control group we do not know how large, if any, the effect(s) of ELM were on student mathematic ability. We also learned about the implementation of ELM in Kenyan classrooms. Instruction would be advantaged as teachers develop greater comfort with using the technology in large classes. Not surprisingly, technology in the computer labs needs to be reliable to maximize learning opportunities for the students in large classes and implementation of cooperative teaching approaches could aid math instruction.

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Sample

Three teachers and their 168 students from two primary schools in Mombasa area, Kenya participated in this pilot designed as a one-group pretest-posttest study. There were two grade-one classes (N=96) and one kindergarten class (72). Informed consent was obtained from the participants following Canada's Tri-Council Policy on the ethical treatment of research participants. Of the 168 students who participated in the ELM field test, 162 participated in the pre- and post-testing. A reduction in sample size occurred after a number of students missed one time of testing: 145 and 141 students completed either pre-test or post-test only. The final sample used for analysis contained the scores of 127 students: 56 kindergarten and 71 grade one students. Gender-wise the group was split as follows: 69 male and 58 female students.
Intervention

In this pilot the teachers followed the Kenyan curriculum requirements for teaching mathematics and were at liberty to decide on the method of classroom instruction as well as the instructional tools and techniques they would use.

In the winter of 2016 the three teachers participating in the pilot attended a one-day initial training workshop on how to use ELM to teach mathematics. Throughout the year they as part of larger team interested in teaching with ELM also attended a number of planning sessions to help them incorporate ELM in Math curriculum. Our ELM coordinator, a master trainer in Numeracy, facilitated these sessions. In addition to the support, these sessions were intended to provide the teachers with a forum to plan their teaching with ELM. Teachers were provided with teaching materials including lesson plans, classroom activities, and job aids for teachers. The use of these materials was suggested rather than prescribed and their use was left at each teacher's discretion. Multimedia scaffolding and support for teachers and students embedded in ELM were also available. Additionally, the numeracy trainer occasionally visited the teachers during the ELM sessions in the lab and by providing feedback on their Math lessons. In total the ELM implementation unfolded between March and September of 2016.

Instrumentation

Students' skills in mathematics were assessed using Group Mathematics Assessment and Diagnostic Evaluation GMADE (Williams, 2004), a standardized achievement measure. Since kindergarten students made about 56% of the pilot sample, we chose to measure the change in the students' mathematic skills using level R, the lowest level of GMADE. This level covers the age band from 5 to 8 years old by offering items at a wide range of difficulty that allows to reliably measure low-, average- and high-performing students. Parallel forms (A or B) were used alternatively to collect pre- and post-data. Each form contained fifty-six multiple choice items measuring concepts and operations addressed by ELM such as counting, comparing, adding, subtracting, decomposing and place value. Level R of GMADE contains the two subtests, Concept and Communication and Processes and Applications.

The Concept and Communication subtest addresses the language, vocabulary and representations of mathematics. The 26 questions contain symbols, words and phrases to assess the five content standards including number and operations, algebra, geometry, measurement, data analysis and probability as reflected by the following categories: comparison, geometry, measurement, numeration, quantity, sequence, and time.
The Process and Applications subtest measures the students' ability to take language and concepts of mathematics and apply the appropriate operation(s) and computation to solve a word problem. At this level the students solve only one-step or single-operation problems. The 26 items assigned to comparison, numeration, quantity and sequence assess the number and operations standard. The items in the geometry category assess the geometry standard whereas time item address the measurement standard.

Analyses

All student data were entered into SPSS 24 for Mac OS X and verified for accuracy. Students for whom the test data were missing were excluded from analyses. Standard screening procedures suggested data normality. Paired sample t-test was run to examine if math scores changed after ELM was used for XXX weeks. In addition, to explore if the gains differed for grade 1 and kindergarten students as well as for male and female students, we performed independent two-sample t-tests of group difference.

Results

The following section presents the results that we obtained after analyzing the student and teacher data.

Student data

First, we attempt to answer the question if after being taught mathematics with the use of ELM, students demonstrated gains in mathematical skills. As table 1 shows ELM students gained in their mathematical skills as measured by the GMADE standardized test. We observed significant improvements on the on the subtests of Concepts and Communications, Process and Applications as well as the total test.

Table 1. *Descriptive statistics (means and standard deviations), t-test values (significance levels with GMADE scores for ELM students (N=127)*

GMADE scales	Post-test Mean score (SD)	Pre-test Mean score (SD)	t-test, p<.000
Concepts and Communication (28)	25.46 (3.01)	22.57 (4.03)	6.70***
Process and Applications (28)	20.98 (6.28)	13.80 (5.36)	12.85***
Total GMADE (56)	46.65 (8.1)	36.46 (7.86)	12.65***

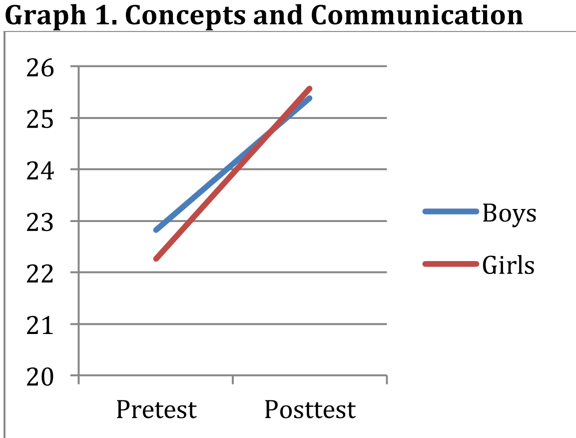
In addition to the main analysis, we examined if gains in mathematics differed for boys and girls. Table 2 shows the results of the analyses of the GMADE gain score differences for boys and girls in ELM classes.

Table 2. *Reading gains by gender in ELM classes*

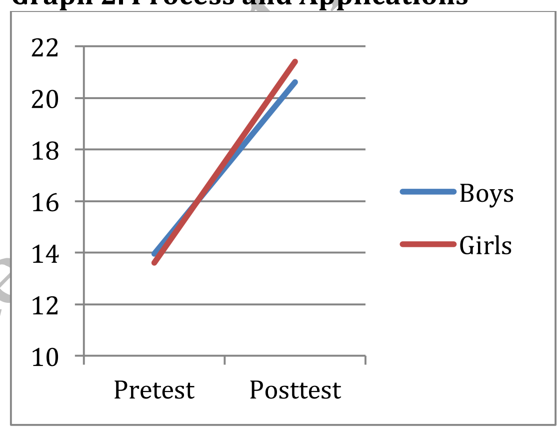
GMADE scales	ELM boys (N=69)	ELM girls (N=58)	F value and significance
Concepts and Communication (28)	2.55	3.31	0.76
Standard Deviation	*4.78*	*4.99*	
Process and Applications (28)	6.65	7.79	1.04
Standard Deviation	*5.65*	*6.97*	
Total GMADE (56)	9.24	11.31	1.64
Standard Deviation	*8.43*	*9.74*	

To visually represent how students of both genders' differed on the GMADE scores, we built Graphs 1, 2 and 3.

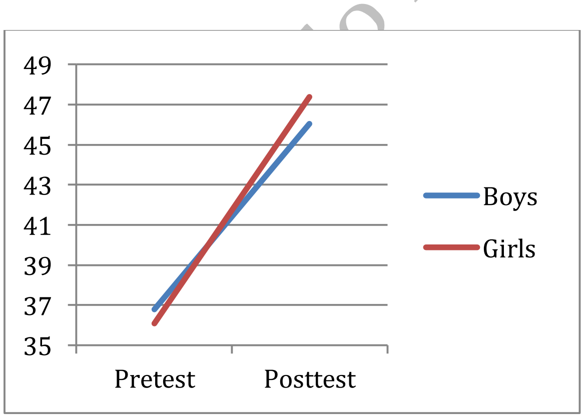
Graph 1. Concepts and Communication



Graph 2. Process and Applications



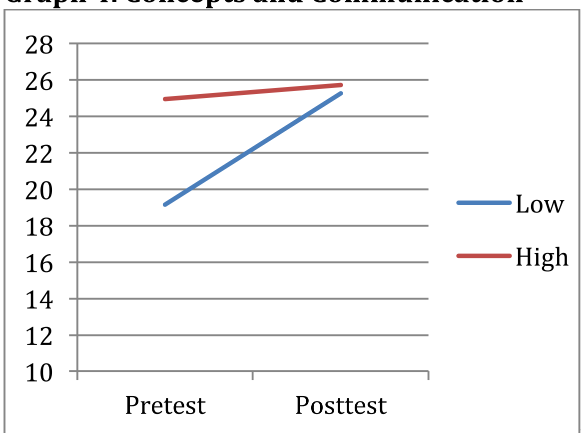
Graph 3. Total GMADE



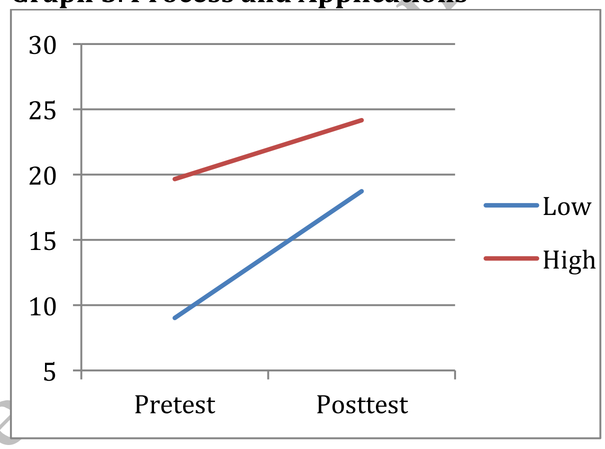
The data summarized in the table and graphs show that girls in the ELM classes demonstrate higher gains than boys on all subtests. However the differences between gain scores for two genders are not statistically significant.

Finally, we compared gains in GMADE scores of those who scored high (N=48) and low (N=47) at the pre-test. The analysis revealed that students in the both groups benefited from the instruction. However, the improvements of low-scored students were significantly higher than those of their high-scored peers on all GMADE subscales including Concepts and Communications (t=6.2, p< .000), Processes and Applications (t=4.3, p< .000) and Test Total (t=6.2, p< .000). Graphs 4, 5 and 6 show how the average scores changed between pre- and post-test implying that the gap between the groups reduced considerably. This is especially noticeable for the Concepts and Communication subscale (Graph.4) where the pre-test disparity became non-existent.

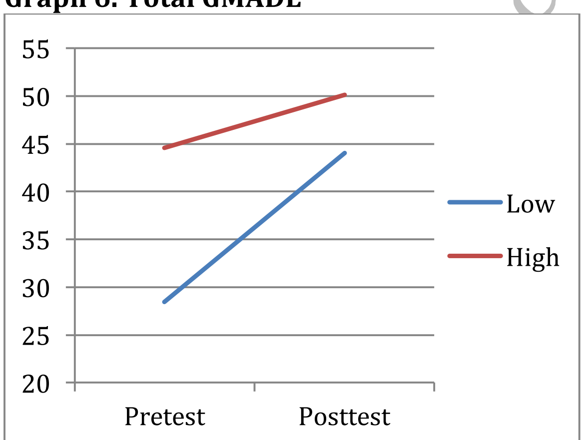
Graph 4. Concepts and Communication



Graph 5. Process and Applications



Graph 6. Total GMADE



Teacher Self-reports

The following information about the classroom implementation of ELM surfaced from the teachers' self-reports. Each class used their school lab with access to ELM. On average the ratio was 5 students per computer. Therefore to increase the exposure time to the technology, teachers placed students in groups due to the large class sizes. In addition to limited access to technology, the teachers reported having experienced a few other important challenges. Among the most recurrent were power black outs, network failures, not working computers and earphones. At the moment of self-reports (term-two, summer of 2016) the classroom uses of ELM in both grade one and kindergarten classes targeted counting activities. The teachers reported having implemented the extension activities provided to them. These were useful as they allowed engaging their large classes in the ELM-covered context while only about 20% of their students could have direct exposure to ELM activities at one time. Teachers reported having used planning and reporting features of ELM; they accessed ELM reports to learn about the progress their students made in ELM activities as well as prepared individual sequence of activities for the students. According to the available self-reports, students also developed skill of using technology and LTK+. According to the teachers, their students "were able to log in and out with ease" as well as developed technology skills such as using the computer mouse. According to the teachers, a having a classroom projector would strengthen teaching as it would allow demonstrating ELM activities to the whole class which is extremely important teaching strategy especially in large classes. In addition to achieving the objectives set on counting, teachers reported that their students were motivated to use the tool: they enjoyed doing puzzles and making new friends; they also liked to work in teams; and completing the activities at their own pace.

Conclusions

The pilot study allowed us to achieve a few goals in regards to the feasibility of using ELM in Kenyan math classrooms. Even given a weak research design we were able to capture learning gains. The results obtained using a standardized test of mathematic achievement (GMADE level R) demonstrated that this measure possesses a sufficient degree of sensitivity to capture the change in mathematic skills for kindergarten and grade-one students between pre- and post-test. Substantially it is important to note that a) the girls in the ELM classes demonstrated higher gains than boys albeit non-significant implying that both genders benefited from ELM about equally; b) the initial pre-test gap between low and high performing students started closing and became non-existent for the subtest measuring language, vocabulary and representations of mathematics. Yet, in the absence of a control group we do not know how large, if any, the effect(s) of ELM were on student mathematic ability.

Secondly, we learned about ELM implementation. For ELM to work in the hands of teacher, the performance of computer labs need to be more reliable to maximize a learning opportunity for the students in large classes. Instruction would benefit as teachers build more comfort using groups in teaching with technology.

Future studies should ensure the systematic data collection on classroom implementation. Classroom observations should be completed in ELM classes at least twice per school year. Regular teacher reports about their use of ELM would be an important complement to the ELM trace data that is collected.