Mathematics from the Beginning: Evaluating the Tayari Preprimary Program's Impact on Early Mathematics Skills

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Abstract

Given the dearth of research on early numeracy interventions in low- and middle-income countries, this paper presents the instructional methodology and impact results of the Tayari program. Tayari is a preprimary intervention in Kenya (2014–2019) that prepares children aged four and five for entry into primary school by providing materials for students, training for teachers, and continuous in-classroom support. The Tayari methodology was built on the Kenyan government's preprimary syllabus to produce instruction that was developmentally sequenced, linked to out-of-school experiences, and supportive of children's number sense. Tayari was evaluated using a randomized controlled trial (RCT) and collection of longitudinal data from 2,957 children in treatment and control schools at three time points. Pupil assessment items were drawn from a growing body of research on preprimary numeracy in developing contexts, plus instruments and techniques from the Measuring Early Learning and Quality Outcomes (MELQO) program (UNESCO, UNICEF, Brookings Institution, & World Bank Group, 2017). The impact evaluation of the longitudinal RCT results showed statistically significant effects in the numeracy tasks of producing sets, identifying numbers, and naming shapes, while revealing no initial effects in the areas of oral and mental addition. We present recommendations for Tayari's improvement in terms of mathematics instruction, as well as preprimary policy implications for Kenya and similar contexts.

Keywords

Mathematics, early childhood, evaluation, numeracy, instruction, sub-Saharan Africa, Tayari

Introduction

There is widespread consensus among researchers and practitioners that mathematical literacy is an essential step toward productive participation in society and economic well-being

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 Citation: Piper, Benjamin, Sitabkhan, Yasmin & Nderu, Evangeline (2018). Mathematics from the Beginning: Evaluating the Tayari pre-primary program's impact on early mathematic skills. *Global Education Review, 5* (3), 57-81.

(Foster, 2010; Hanushek & Woessmann, 2008; Wiest, Higgins, & Frost, 2007). In addition, there is increasing evidence that mathematical literacy develops very early in life, and early interventions are crucial to support the development of more sophisticated mathematics (Duncan et al., 2007; Duncan & Magnuson, 2011; Siegler et al., 2012). Despite this awareness, there is a lack of rigorous research from sub-Saharan Africa about what types of instruction work to build mathematical knowledge with preprimary children. Instead, much of the evidence we have on effective teaching practices in preprimary settings comes from Western and Asian countries. Although the number of preprimary mathematics interventions in sub-Saharan Africa is growing, few describe instructional practices in sufficient detail to add to our collective knowledge of best practices.

In this study, we report on the design and impact of the Tayari program, a multiyear intervention intended to improve numeracy and literacy outcomes of 4- and 5-year-olds. The study was conducted in four counties and informal settlements in Kenya. The Tayari program prepared carefully sequenced and developmentally appropriate materials for classrooms, including teachers' guides with daily scaffolded lessons and an accompanying student book. Professional development was provided to teachers on how to use the materials, including guidance on incorporating locally available resources into mathematics lessons. The researchers followed up the face-to-face professional development with in-classroom support provided by government officers supporting early childhood development and education (ECDE). The program continues to be implemented through government structures at the county level, so if Tayari is determined to be highly effective, it will be much more likely that the impacts experienced in Tayari can be scaled up (Gove et al., 2017).

Literature Review

Few studies have focused on preprimary mathematics in sub-Saharan African countries (Amente et al., 2013; Hembold, 2014; Martinez, Naudeau, & Pereira, 2013). Martinez and colleagues (2013) evaluated an early childhood program developed and implemented by Save the Children in Mozambique. The program employed a community-based model in which communities were given the responsibility to build and staff early learning centers, with support from Save the Children. As part of this support, community volunteers were provided with classroom materials, training, and follow-up support to implement an instructional program. Numeracy activities consisted of a daily 25-minute Math Circle, which included "activities to teach children numbers, shapes, time, and dates" (Martinez et al., 2013, p. 15). The authors reported that the math activities were aimed at building problem-solving skills and exposing children to foundational math skills.

The study used an RCT, with 30 schools in the treatment group and 47 schools in the control group. Surveys and direct child assessments were administered through a household survey, In addition, for a subsample of students, Grade 1 teachers were asked to fill out an observational checklist. The observational checklist revealed that children who attended a community center scored significantly higher on the Cognitive Development and Language measures than children who did not attend a community center, with an average score increase of 12.1 points. There were also significant increases in subskills: for example, children who attended a community center were rated higher by teachers in the skills of one-to-one correspondence, counting to 20, and comparing and contrasting numbers than children who did not attend a community center. A direct child assessment administered during the household survey showed that children in the treatment group had scores on problem-solving tasks that were 6.4 percentage points higher on average than for the control group. However, no information was reported about the nature of the problem-solving tasks.

While the study by Martinez and colleagues contributed to the evidence base of the positive short-term effects of an early childhood numeracy program, it did not detail the instructional practices sufficiently to explain how children's mathematical development was fostered. The authors indicated that children engaged in activities with objects, and that instruction emphasized problem solving, but did not supply enough information to contribute to overall knowledge of best practices in sub-Saharan African preprimary mathematics classrooms.

To shed more light on mathematics instructional practices from the global South, we turned to two preprimary math studies outside of sub-Saharan Africa. Opel, Zaman, Khanom, and Aboud (2012) and Näslund-Hadley, Parker, and Hernández-Agramonte (2014) both adapted a preprimary math program developed in the US, called *Big Math for Little Kids* (Lewis Presser, Clements, Ginsburg, & Ertle, 2015). Opel et al. (2012) focused on adapting activities from the program and implementing them in nine schools in Bangladesh. Näslund-Hadley and colleagues (2014) adapted the same program in Paraguay, using audio to deliver the lessons. Both programs showed gains in learning (2.68 standard deviations *[SD]* in Bangladesh, 0.16 *SD* in Paraguay). Because both interventions relied on a program that was already established and documented in the literature, we can learn from the instructional methodology that was used to produce the learning gains.

For example, Opel et al. (2012) described how activities were created that could be implemented in either small groups or larger groups. Children were actively encouraged to manipulate objects. The authors described how "One child would make a sequential pattern with colored blocks or foam shapes, and the partner would state the rule and continue the pattern" (Opel et al., 2012, p. 106). The authors also detailed how the instruction in treatment schools differed from instruction in control classrooms. More information like that detailed in the studies above is needed from sub-Saharan Africa to be able to compile best practices in preprimary mathematics.

While there is no available published evidence on the impact of ECDE programs in numeracy in Kenya, a recent study investigated the causal impact of an early primary education program called the Primary Math and Reading (PRIMR) Initiative on numeracy outcomes, as measured by the Early Grade Mathematics Assessment (EGMA). The PRIMR program was similar to Tayari in that it was implemented using government officers, it focused on practical skills that teachers could utilize, and it supported teachers with teachers' guides. The impact of PRIMR was larger in Grade 2 than in Grade 1, with somewhat larger impacts on a procedural index of numeracy outcomes than a conceptual index (Piper, Ralaingita, Akach, & King, 2016). This program was scaled up nationally through the Primary Education Development (PRIEDE) program (2015–2019), funded by the Global Partnership for Education. The fact that the impacts of PRIMR were larger in Grade 2 than in Grade 1 is interesting, but somewhat discouraging for the potential impact of Tayari on ECDE numeracy outcomes. Similarly, the PRIMR results informed Tayari's emphasis on conceptual skills rather than simple procedural impacts on computation, but suggested that the challenge for Tayari would be substantial.

ECDE Background in Kenya

Kenya's Basic Education Act (Republic of Kenya, 2013) established that basic education in Kenya would include two years of preprimary education. The Kenyan government's curriculum and education framework includes an expectation for all children to have access to preprimary education.

The Kenyan constitution (Republic of Kenya, 2010) gave counties in Kenya the mandate to manage preprimary education. County governments manage preprimary education by hiring teachers, providing educational materials, and making capital investments in the preprimary subsector. On the other hand, Kenya's national government oversees preprimary education policy, particularly through the recently created ECDE directorate. Counties are mandated to adapt the existing ECDE policy to suit their local situation, although research suggests that this is relatively difficult for counties to do without the necessary technical expertise required to do so (Piper, Merseth, & Ngaruiya, 2018).

The national government has been expanding its role in creating the policy environment for effective ECDE interventions in the country. The new ECDE directorate has managed the development of a new ECDE policy, which awaits an official launch by the government after the rollout of a new preprimary and primary curriculum in early 2018. This policy will ensure that the key ministries that are assigned to various ECDE functions are familiar with their role in ECDE and reduce overlap of provision of services. The policy will also guide counties in the specific aspects of preprimary education service delivery (Ministry of Education [MOE], 2017).

Recent statistics have shown that the demand in Kenya for preprimary education has grown to one of the highest rates in sub-Saharan Africa. The overall gross enrollment ratio for early childhood education increased from 69.4% in 2012 to 76.6% in 2016, while the net enrollment ratio increased from 66.9% in 2013 to 74.9% in 2016 (Republic of Kenya, 2017). Kenya provides ECDE services through a combination of private, public, and low-cost private providers, increasing the complicated task of managing the diverse sector, but allowing a more flexible approach that meets the needs of local communities. Note that low-cost private schools are referred to as Alternative Provision of Basic Education and Training (APBET) institutions in Kenya. Although Kenya's enrollment rates have been below the recommended Sustainable Development Goal of 80%, the recent increase in enrollment may partially be attributed to the increasing economic pressure on families, which results in all of a household's caregivers having to work, therefore compelling them to seek child care services.

Tayari Preprimary Program in Kenya

The Tayari program is structured to provide low-cost implementation solutions to the Kenyan national and county governments, with the explicit goal of improving preprimary quality, to increase school readiness. School readiness refers to a holistic measure of a child's ability to successfully learn in primary school. Tayari initially was funded by the Children's Investment Fund Foundation (CIFF) from 2014 to 2018, and recently was extended to 2019 by CIFF. The program is a collaboration among the Kenyan Ministry of Education, technical ECDE officers from four counties chosen by the MOE for Tayari implementation, the Ministry of Health teams in those four counties, the low-cost private school providers randomly selected by the program (Zuilkowski, Piper, Ong'ele, & Kiminza, 2017), and RTI International, which has provided technical support to the program.

As indicated above, Tayari is a preprimary program that supports teachers and 4- and 5-year-old children. The Kenyan curriculum calls these classes Pre-primary 1 (PP1) and Pre-primary 2 (PP2), respectively. The Tayari program developed learning materials for both PP1 and PP2, and the implementation of the program in 2016 and 2017 covered both PP1 and PP2 classrooms. In addition to undergoing an external evaluation, Tayari also collected longitudinal data from 2,957 children from one of three Tayari treatment conditions and the corresponding control schools. The three treatment groups in the Tayari program are (1) Training & Support; (2) Training & Support + Books/Teachers' Guides; and (3) Training & Support + Books/Teachers' Guides + Health. The longitudinal study focused on the second treatment group, which was the intervention that was found during the external evaluation to be most effective (African Population and Health Research Center [APHRC], 2018).

The advantage of the design of the Tayari longitudinal study was that it allowed for an analysis of the impact of Tayari through the entire course of the program, as the same children's baseline scores were drawn from the beginning of their PP1 year, their midpoint scores were drawn from the end of their PP1 year, and their final scores were drawn from the end of their PP2 year. The impacts identified in this paper, then, allow for an analysis of the overall impact of Tayari on numeracy learning outcomes from PP1 to PP2.

Starting in 2015, the Tayari technical team worked with teams from the MOE, counties, and the government's Kenya Institute of Curriculum Development (KICD) to ensure that the Tayari materials and approaches followed the KICD curriculum. This collaboration resulted in the materials used in 2016 and 2017—and evaluated indirectly in this study—being approved by KICD. In addition, the Tayari technical design ensured that the training of the ECDE officers and support to teachers, both face-to-face in-service teacher professional development and classroom-based coaching support, was provided by county-level education officers—in other words, government employees earning salaries from the county level. To summarize, the training materials, coaching system, teachers' guides, and learning materials developed for the Tayari program were developed by the KICD, MOE, and county teams, with technical support from RTI.

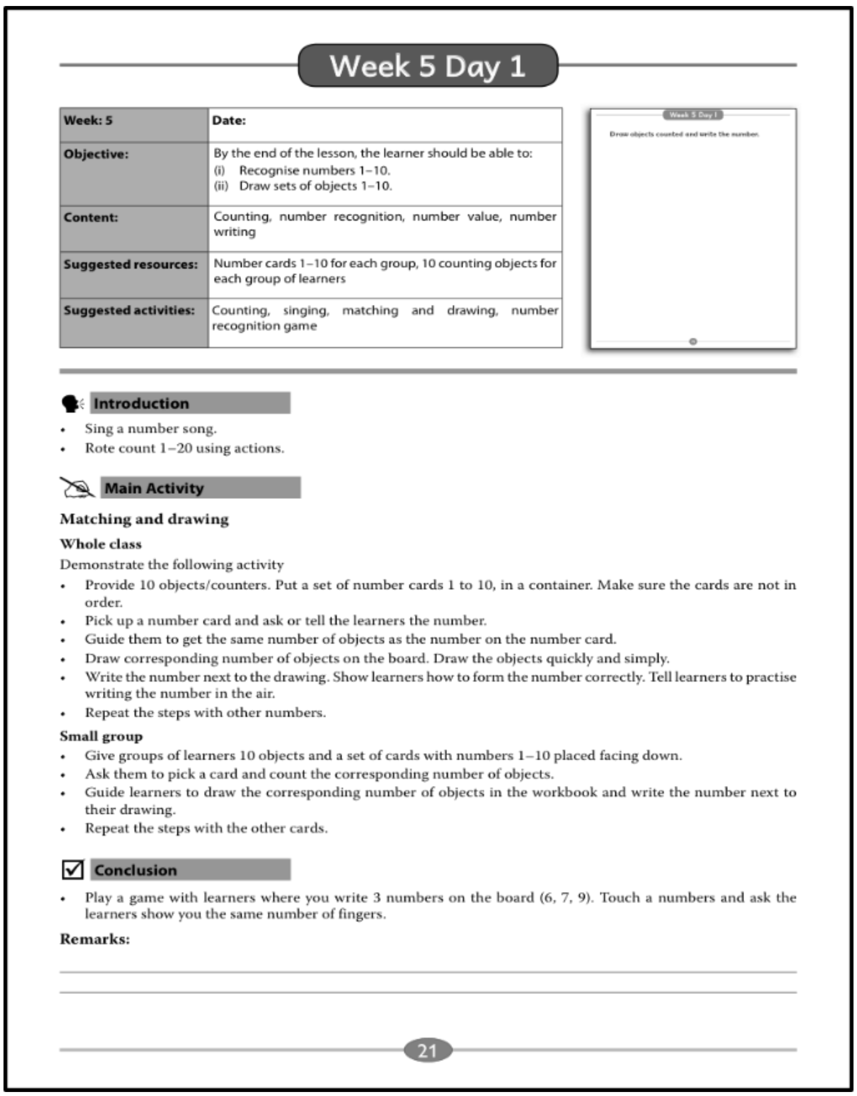
APHRC's external evaluation results suggested meaningful impact on school readiness in two of the three treatment groups (APHRC, 2018). Whereas the program was externally evaluated using a cross-sectional differences-in-differences identification strategy, CIFF and the MOE also decided to capture a longitudinal subsample of one of the treatment groups, not only to understand whether the program was working, but also to see how skills transitioned within children over time. We present the results of the within-child longitudinal study below.

Tayari Numeracy Program

Tayari has supported several school subjects, according to the Kenyan curriculum: language, numeracy, life skills, and social skills. The APHRC evaluations also included a measure of overall school readiness encompassing a range of literacy, numeracy, socioemotional, and executive-function skills (APHRC, 2018). The longitudinal study evaluation expanded beyond the external evaluation in several ways, including incorporating additional numeracy items that allowed for a more detailed analysis of the impact of Tayari on children's numeracy skills. The analysis was drawn from six separate numeracy tasks and an overall numeracy index score.

The developers of the Tayari numeracy materials followed several core principles. First, all lessons were structured in such a way as to encourage active student participation. Second, the lessons were sequenced using a spiral curriculum approach. The spiral approach covers mathematical concepts over time, as compared with a "blocked" approach, where content is presented in chunks (Pashler et al., 2007). If implemented correctly, a spiral approach mirrors children's natural learning styles by frequently revisiting core concepts (Son & Simon, 2012). Finally, Tayari lessons focused on giving students opportunities to build conceptual understanding, and attempted to move away from rote learning and memorization. This is relevant given the finding that the Kenya PRIMR study showed larger impacts on procedural than on conceptual skills (Piper, Ralaingita et al., 2016).

To encourage active participation by students, often in environments with large class sizes and limited physical resources, numeracy lessons were designed in such a way as to enable teachers to facilitate small-group work during every lesson. Each lesson in the teachers' guide was divided into an introductory section; a main activity—consisting of a whole-group and a small-group section; and the conclusion of the lesson, as seen in Figure 1. The main task always consisted of one activity, which the teacher first modeled and explained during the whole-class section. This same activity was then carried out by students in small groups, with the teacher providing support as needed to the groups. Almost all small-group activities used counters or other locally available materials, and efforts were made during activity design to minimize the diversity of resources, to ease the burden on the teacher of collecting many different manipulatives and other supplies.



Week 5 Day 1

Week: 5	**Date:**
Objective:	By the end of the lesson, the learner should be able to: (i) Recognise numbers 1–10. (ii) Draw sets of objects 1–10.
Content:	Counting, number recognition, number value, number writing
Suggested resources:	Number cards 1–10 for each group, 10 counting objects for each group of learners
Suggested activities:	Counting, singing, matching and drawing, number recognition game

Introduction

- Sing a number song.
- Rote count 1–20 using actions.

Main Activity

Matching and drawing

Whole class

Demonstrate the following activity

- Provide 10 objects/counters. Put a set of number cards 1 to 10, in a container. Make sure the cards are not in order.
- Pick up a number card and ask or tell the learners the number.
- Guide them to get the same number of objects as the number on the number card.
- Draw corresponding number of objects on the board. Draw the objects quickly and simply.
- Write the number next to the drawing. Show learners how to form the number correctly. Tell learners to practise writing the number in the air.
- Repeat the steps with other numbers.

Small group

- Give groups of learners 10 objects and a set of cards with numbers 1–10 placed facing down.
- Ask them to pick a card and count the corresponding number of objects.
- Guide learners to draw the corresponding number of objects in the workbook and write the number next to their drawing.
- Repeat the steps with the other cards.

Conclusion

- Play a game with learners where you write 3 numbers on the board (6, 7, 9). Touch a numbers and ask the learners show you the same number of fingers.

Remarks:

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Figure 1. A PP2 Tayari lesson for 5-year-olds

As described earlier, Tayari mathematics lessons were designed using a scope and sequence developed by the MOE, KICD, and RTI team, based on the spiral approach. Key concepts such as number quantity and number recognition were integrated into specific activities, creating a core set of activities. These activities were then repeated throughout the year, with increasing complexity, and based on established developmental progressions. In addition, some concepts were identified for which additional exposure would benefit the children more. For example, counting and shape identification were included as part of daily routines several times a week, given their essential contribution to key numeracy skills. In this way, children were exposed to these skills over time.

The annex to this paper contains one week's worth of lesson plans from the teachers' guide for the Tayari PP2 numeracy program. The lessons were delivered at a rate of one page per day, and focused on the particular behaviors that the Tayari teachers had learned to model and practice during their professional development (Piper, Sitabkhan, Mejia, & Betts, 2017). The Tayari lessons presented in the annex show how the simple activities progressed over time, and the simplicity of the teachers' materials, such that the lessons both were easy to implement and fostered the development of mathematical skills in children.

Beyond lesson structure and sequencing, the third core principle of the Tayari design aimed to change the environment of the early math classroom from memorizing numbers and procedures, to developing conceptual understanding of foundational topics. Number identification, for example, occurred alongside references to the quantity of the number, and often involved comparisons between quantities. Addition and subtraction did not use the formal symbols or number sentences, but instead focused on the concepts of putting together and taking away. With shape identification, children observed shapes in different sizes and orientations, and were asked to compare features of the shapes. All of these activities emphasized the development of conceptual understanding rather than memorization. A typical Tayari numeracy classroom would have somewhat less procedural practice and significantly more conceptual activities.

Research Questions

Given the dearth of research on the impact of ECDE programs on numeracy outcomes, and given the unique opportunity that the Tayari ECDE longitudinal study offered, we asked the following research questions:

RQ1: What is the impact of Tayari on preprimary numeracy outcomes?
RQ2: Does the impact of Tayari differ by preprimary numeracy task?
RQ3: Do numeracy skills at baseline predict overall school readiness?
RQ4: If Tayari does have numeracy effects, do they persist in Grade 1?

Tayari Research Design

Overall Design

Tayari was designed as an impact evaluation, allowing for causal estimates of the impact of Tayari's interventions on school readiness. As indicated earlier, the data presented here are from the longitudinal study within Tayari, which followed children from PP1 through the end of PP2; and came specifically from the portion of Tayari that was implementing the second treatment, which was shown by the APHRC external evaluator to be the most effective of the three overall Tayari treatment groups (APHRC, 2018).

Tayari, in collaboration with the external evaluator, used the data from the four Tayari counties, which had been chosen by the MOE, to create comparison groups. All of the zones in each of the counties were eligible for selection into the study, and then assignment into the various treatment groups. The zones were randomly selected and selected zones were randomly assigned to the treatment groups or the control group. All of the schools within each zone received the same treatment. This approach had the advantage of being more relevant to the actual situation in countries like Kenya, where one zone is staffed by one ECDE officer, such that having them all receive the same treatment was more likely to mirror what would occur at a larger scale than would assigning treatments to individual schools. The impact of this research design, statistically, was that it required the standard errors for the impacts to account for the clustering design, thereby decreasing the likelihood that statistically significant effects could be identified.

Power calculations for the design of Tayari's impact evaluation used assumptions derived from the PRIMR program that was implemented in Kenya before Tayari (Piper, Kwayumba, Oyanga, & Oyagi, 2018). To have a minimum detectable effect size of 0.2 *SD,* we assumed power of 80%, an ECDE center-level intra-class correlation of 0.249, proportion of variation explained by the ECDE center covariance of 0.50, 10 pupils for PP1, and a significance level of 0.05. As we show below, some of these assumptions did not hold, and the tools used in Tayari were slightly noisier than the Early Grade Reading Assessment (EGRA) and EGMA tools that preceded it in PRIMR.

The research team for the longitudinal study selected a total of 176 schools for the treatment and control groups, and targeted 10 pupils in both PP1 and PP2 (i.e., 20 pupils per school) in the initial data collection in January 2016. If there were more than 10 pupils in PP1 in those ECDE centers, the researchers used systematic random sampling to select the pupils for the assessment, which was done separately for boys and girls. Evaluators assessed 3,257 children for the baseline assessment, found 2,891 of them in the October 2016 midterm assessment, and ultimately assessed 2,647 of the original 3,257 children during the October 2017 final assessment, as Table 1 shows. This resulted in an 18.7% overall attrition rate, which is significantly lower than in previous research in Kenya (Piper, King, & Mugenda, 2016). The attrition was highest in the peri-urban or slum areas of Nairobi served largely by APBET schools, which is unsurprising given the transient nature of those areas traditionally.

Table 1.
Tayari longitudinal study: Attrition results

	Number of pupils at each evaluation point									Percentage attrition		
	Baseline (Jan 2016)			Midterm (Oct 2016)			Final (Oct 2017)					
County	**Control**	**Treat-ment**	**Total**	**Control**	**Treat-ment**	**Total**	**Control**	**Treat-ment**	**Total**	**Control**	**Treat-ment**	**Total**
Laikipia	339	522	861	283	462	745	267	417	684	21.2	20.1	20.6
Nairobi	169	211	380	146	179	325	134	163	297	20.7	22.7	21.8
Nairobi APBET	334	232	566	262	202	464	240	184	424	28.1	20.7	25.1
Siaya	436	319	755	410	297	707	371	270	641	14.9	15.4	15.1
Uasin Gishu	371	324	695	346	304	650	319	282	601	14.0	13.0	13.5
Total	**1,649**	**1,608**	**3,257**	**1,447**	**1,444**	**2,891**	**1,331**	**1,316**	**2,647**	**19.3**	**17.5**	**18.7**

Source: Piper, Kwayumba et al., 2018.

Tayari Study Instruments
The Tayari study included several research tools. Relevant to this study are the direct assessment tool, taken by the pupils in a one-on-one assessment with an experienced assessor; and the pupil background questionnaire, which focused primarily on indicators of socioeconomic status. This tool was also administered in a one-on-one discussion. The direct assessment tool was derived from the Monitoring Early Learning and Quality Outcomes (MELQO) tool, which is a recent preprimary assessment tool used in several countries (UNESCO et al., 2017). For the numeracy area, Table 2 presents the numeracy assessments analyzed in this study.

For the longitudinal assessments, at all three time points, assessors were selected from a database of experienced assessors who had worked in Kenya with RTI on EGRA, EGMA, and Tayari assessments since 2010. Assessors were trained for five days, with the numeracy portion of the assessment taking up a significant amount of that training period. Assessors piloted the tools in schools in Nairobi during the training period, and underwent interrater reliability (IRR) assessments. The average IRR score for the assessors who undertook the baseline Tayari assessment was 96.5%; at midterm, 96.0%; and at the final assessment, 97.0%.

Data were collected using the RTI-developed Tangerine® open-source software application on tablets. Data were uploaded from the field daily so that quality control for missing data could be undertaken right away. This was particularly important for the longitudinal study, as it was essential that each pupil assessed in previous rounds also be found during the final study in October 2017. Following individual pupils was particularly complicated due to the national elections that were held in August and

Table 2.
Numeracy assessment items

Instrument task	Description	Number of Items	Sample task
Shape naming	Percentage of shapes correctly identified	3	Child was shown different shapes and asked, “Can you point to three items that look like a circle?”
Number identification	Percentage of numbers correctly identified	20	Child was shown numerals 1–10 out of order, then 11–20 out of order, and asked to identify each numeral.
Producing a set	Percentage of sets of bottle tops correctly produced	3	Child was told, “Now we’ll play a game with bottle tops. Please give me three bottle tops.”
Quantity discrimination	Percentage of quantities correctly discriminated	3	Child was asked, “Which number is bigger? 8 or 5?”
Mental addition and subtraction	Percentage of mental addition and subtraction items correctly solved	2	Child was asked, “If you have three balls, and I give you four more balls, how many balls will you have all together?”
Oral addition and subtraction	Percentage of oral addition and subtraction items correctly solved	5	Child was asked, “If you add 1 and 2, what number do you get?”

October 2017, as they caused a significant disruption to learning time, and many children were not found in the schools in which they were initially assessed due to the election uncertainty. The attrition rate of 18.7% suggests that Tayari's identification efforts were mostly successful, but the reality is that many of the children who were counted as being supported by Tayari had limited exposure to the treatment. However, we present the intent-to-treat impacts in this paper, as they represented the most conservative estimate of Tayari's effects.

We conducted reliability analyses of the numeracy assessment tasks presented below to determine internal consistency. Simple calculations showed correlations between each of the numeracy tasks, and overall Cronbach's alpha scores of 0.75 and 0.77 for the baseline and final Tayari assessments, respectively (Kwayumba & Piper, 2016; Piper, Kwayumba et al., 2018).

Evaluation Design and Analysis

In this section we describe the identification strategy that we used to evaluate Tayari's impact on numeracy outcomes. As shown above, a total of 2,647 students were assessed at each of the three data points for Tayari. Of these, 930 began in PP1, and therefore were the students on which we undertook most of the analyses, as they were expected to complete the two years of Tayari's intervention. The randomization process and longitudinal nature of this study made the identification strategy simple. Each child had numeracy outcomes at three data points. The simplest analysis that we present takes the numeracy outcomes in January 2016 and measures the gains in those outcomes between the baseline and the final assessment in October 2017. The impact evaluation used a simple ordinary least squares (OLS) regression model to compare whether there were statistically significant differences between treatment and control children on those gains in numeracy outcomes.

The analyses were done in Stata using the svy suite of commands. This ensured that the estimates provided were from the weighted sample and therefore would be externally valid to the four counties and APBET settings in which Tayari is being implemented. This approach also accounted for the nested nature of the Tayari design, and the fact that schools were clustered in zones that were supported by specific ECDE officers and where teachers were trained at zonal sites.

To obtain a simple measure of numeracy impacts, and drawing from previous research on numeracy in Kenya (Piper, Ralaingita et al., 2016), we created a Tayari numeracy index. This index was simply the average of the six numeracy measures presented in Table 2 above, which simplified the analysis somewhat.

As described above, the basic model fit to provide these impacts was a simple comparison between treatment and control on the gains in the individual items between January 2016 and October 2017, or on the overall index. Given that the measures adopted from the MELQO tool proved to be somewhat more unsteady than the EGRA and EGMA measures before them, and that there were severe ceiling effects to some of the measures, judging by the high scores at the final assessment, we had to include another model with control variables to increase precision. The model with controls included fixed effects for county, since the attrition varied greatly by county, as did learning outcomes. The control model also included a dichotomous variable that differentiated children who spoke the local language of the county within their household from those who spoke either English or Kiswahili. This variable had little impact on numeracy outcomes, but since it was included as a key variable for the literacy and overall assessment measures presented in the larger

Tayari impact analysis, we added it to the longitudinal regression model (Piper, Kwayumba et al., 2018).

Findings

Our first research question investigated whether the Tayari program had an impact on numeracy outcomes. We found that Tayari improved numeracy outcomes by 0.31 *SD* in the control model (*p*-value < .05) and by 0.29 *SD* in the base model (*p*-value .07); see Table 3. These findings suggest that increased precision is needed for the Tayari impact analysis, which was designed to be able to identify a 0.2 *SD* minimum detectable effect size. The lack of statistical significance in the 0.29 *SD* effect size in the base model is evidence of the volatility of the Tayari MELQO-derived measure and also a reason to utilize a model with control variables. A 0.31 *SD* impact of Tayari is substantial. However, the overall impact of Tayari did not change between the midterm and final assessments, as the midterm report showed a 0.31 *SD* impact on PP1 at the October 2016 midterm assessment (Kwayumba, Piper, Oyanga, & Oyagi, 2017).

Our second research question examined whether the impact of Tayari differed by preprimary numeracy task. When we used the model with controls, we found statistically significant impacts of 0.25 *SD* for number identification (*p*-value < .05), 0.34 *SD* for producing a set (*p*-value < .01), and 0.38 *SD* for shape naming (*p*-value < .01). We found a marginally statistically significant positive impact of 0.20 *SD* for quantity discrimination (*p*-value .07), a marginally statistically significant negative impact of –0.14 *SD* on mental addition and subtraction (*p*-value .08), and no impact on oral addition (*p*-value .73). It appears that the overall Tayari index impact masked wide ranges of impacts on learning outcomes in the Tayari numeracy program.

Table 3. *Impact of Tayari on numeracy in base model without controls, and on model with controls*

	Base model				**Model with controls**			
Measure	**Tayari impact on percentage correct**	***p*-value**	**Statistical significance**	**Effect size**	**Tayari impact on percentage correct**	***p*-value**	**Statistical significance**	**Effect size**
Tayari numeracy index	5.84	.07	~	0.29	6.26	.03	*	0.31
Number identification	6.51	.04	*	0.23	6.87	.04	*	0.25
Producing a set	12.65	.01	*	0.34	12.63	.003	**	0.34
Shape naming	14.91	.06	~	0.32	17.52	.004	**	0.38
Oral addition	–1.53	.77		–0.04	–1.82	.73		–0.05
Quantity discrimination	7.75	.07	~	0.19	6.78	.07	~	0.16
Mental addition and subtraction	–4.95	.07	~	–0.16	–4.27	.08	~	–0.14

When we compared the results of the base model and the control model, we found somewhat increased precision for the overall numeracy index result and the shape naming task, but few changes in the effect size of the impacts, with the control model actually decreasing the effect size of the quantity discrimination item.

Our third research question asked whether baseline numeracy skills predicted school readiness. We found that the mean numeracy index score at the baseline was 25.6% correct and that initial numeracy skills accounted for 21.0% of the variation in overall school readiness two years later. It mattered much more for the children in control schools, as their baseline school readiness score accounted for 26.7% of the variation in their final school readiness results, as opposed to 11.7% for children randomly assigned to treatment ECDE centers.

Our fourth research question examined the larger Tayari longitudinal data set to investigate whether the Tayari numeracy effect persisted among children who were exposed to Tayari for only one year, and then moved on to primary school. Table 4 presents the results of these analyses. The first row is the impact of the Tayari numeracy program on the gains in the numeracy results for pupils who began in PP2 in 2016, most of whom would have been in Grade 1 in 2017, when the final assessment was conducted. The results show that there was no statistically significant impact of Tayari on these children's numeracy skills, either for the base model (*p*-value .18) or for the model with controls (*p*-value 0.18). The next row, for the children who were in Combined classrooms (i.e., with both PP1 and PP2 children) in 2016 showed some positive results. In other words, these children began their Tayari intervention in 2016 in classrooms that had some PP1 and some PP2 children in them, so some of these children would have received two years of Tayari numeracy interventions. Table 4 shows that, while the 0.28 *SD* effect size in the base model was not statistically significant (*p*-value .10), a similar 0.28 *SD* effect size was significant in the model with controls (*p*-value .03), and that the Tayari program increased their gains in the Tayari index by 6.7 percentage points.

Discussion

The Tayari impact evaluation (APHRC, 2018) showed whether Tayari had an impact on a range of school readiness skills, and the longitudinal study of Tayari examined the pathways of growth for children in an expanded number of skills (Piper, Kwayumba et al., 2018). The analyses presented in the findings section above examined with specificity the impact of Tayari on an expanded numeracy index. We found that Tayari improved numeracy index results by 0.31 *SD*

Table 4.

Impact of Tayari on numeracy for children who began 2016 in either PP2 or in a Combined classroom in base model without controls, and in model with controls

	Base model				Model with controls			
Cohort	**Tayari impact (percentage points)**	***p*-value**	**Statistical significance**	**Effect size**	**Tayari impact (percentage points)**	***p*-value**	**Statistical significance**	**Effect size**
PP2 in 2016	4.27	.18	—	0.20	3.30	.18	—	0.16
Combined in 2016	6.56	.10	—	0.28	6.70	.03	*	0.28

for children who began in PP1 and would have been eligible to receive two years of Tayari interventions. We also found no difference in the magnitude (0.31 *SD*) of the impact of Tayari for those who received two years of the intervention (Kwayumba et al., 2017). Compared with previous research using rigorous methods to estimate the causal impact of numeracy interventions in preprimary, the Tayari intervention's results were robust and represented a larger scale than that identified in other settings. It points to the potential for impact using the approach to improved numeracy developed and used by the Tayari numeracy program, particularly because the numeracy results in Tayari were larger than for the literacy program (Piper, Kwayumba et al., 2018).

The overall results discussed above masked meaningful differences in the impact of Tayari by numeracy task. As shown above, by effect size, the Tayari impact on gains was largest for the number identification, shape naming, and producing a set tasks. The fact that these were the tasks that demonstrated the largest causal impact of Tayari can be explained in the context of Tayari's spiral approach, where mathematics content was frequently revisited and presented to children throughout the year. For example, for identification of basic shapes, "shape hunts" and "shape comparison" games were part of introductory activities during a lesson every week. Children had the opportunity to identify and describe attributes of shapes presented in different orientations and sizes, and participated in discussions that compared the features of one shape to another shape. Similarly, the Tayari lessons included weekly activities focused on producing sets, with increasingly larger set sizes being produced as the program progressed.

The impact evaluation results showed no impact on the oral addition task. The Tayari mathematics program design aimed to move children to conceptual understanding, with little emphasis on procedural tasks; thus, at this age, solving formal addition and subtraction problems was not included in the Tayari materials and lessons. Instead, there was emphasis on the concepts of putting together and taking away using concrete objects, and supporting children to build flexibility with number combinations.

Given the emphasis in Tayari on the conceptual underpinnings of operations, rather than the predominant memorization of number facts that took place in control schools in Kenya, it is surprising that we found no impact on mental addition and subtraction, although the direction of the impact was negative at the .10 level. The mental operations task that showed no Tayari effect was focused on the concept of putting together and taking away, which we assumed would have shown an impact given its inclusion in the lesson design. During the analyses of the results of the midterm Tayari assessment, the researchers examined whether children took advantage of the opportunity to use concrete objects which were provided to them (bottle tops) to solve the task item. They found that few children actually used these objects, and that while more children from treatment ECDE centers used the objects, the difference was small (12.8% compared with 10.6% for one item). It appears that, for some reason, children did not feel comfortable using the concrete materials during the one-on-one assessment. Because the lessons emphasized the use of concrete materials to solve simple addition and subtraction problems, it may be that children did not have a repertoire of strategies to solve these problems without concrete materials. Future revisions of the Tayari implementation design should take this into account, and provide children with multiple means to solve a mathematics problem.

One of the advantages that the Tayari longitudinal study offered to researchers was the ability to examine how initial skills affected growth in skills over time. We were able to fit models that examined whether initial numeracy skills as measured at baseline, when the children were beginning their first month of PP1 (typically at 4 years old), had a predictive relationship with their overall school readiness results. If so, then supporting numeracy skills in ECDE arguably would have a meaningful place in the design of future ECDE interventions. In Tayari, measures of initial numeracy skills predicted 21.0% of the final school readiness outcomes, a meaningful amount. Interestingly, numeracy skills in control ECDE centers mattered more, as the baseline numeracy skill set predicted 26.7% of overall school readiness, compared with only 11.7% of the variation in ECDE centers benefiting from Tayari. It appears that Tayari was able to reduce the gaps in initial numeracy skills and their predictive relationship with school readiness, and provide more equitable opportunities for school readiness than occurred in control schools. It may be that the simple, repetitive design of Tayari lessons gave children multiple opportunities to develop competencies in foundational concepts. This is an encouraging finding, since it suggests that children's weaknesses at the beginning of ECDE and preprimary can be overcome with focused interventions, even in developing countries with limited resources.

Our primary analytic focus was the impact of Tayari on learners who received the full course of the two-year intervention. The availability of longitudinal data allowed us to examine whether just one year of intervention was sufficient for improved school readiness and outcomes. The results showed that, for children who began Tayari in 2016 in PP2, and were eligible for only one year of the impact, the effect of Tayari faded out by the end of their Grade 1 year. This is concerning, given that this population of children was identified with a 0.34 *SD* effect at the end of their PP2 year (Kwayumba et al., 2017). That effect reduced to either 0.20 or 0.16 *SD* depending on whether the base model or controlled model was preferred at the end of Grade 1. Sadly, this fadeout effect of ECDE interventions on short-term cognitive gains is typical (Bailey, Duncan, Odgers, & Yu, 2017; Mervis, 2011) One possible culprit in the loss of short-term gains from ECDE programs may be a lack of coherence between pedagogy and content in ECDE classrooms, and what children encounter in Grade 1. In Kenya, there is a sharp disconnect between methodology and content between preprimary and primary, starting at the national level with the syllabus, all the way to the classroom experiences of children. Note that the longer-term effects of ECDE on secondary graduation and future earnings have been well established (McCoy et al., 2017).

For Tayari, we were interested to know whether this reversal of gains was due to an actual fadeout effect that would affect Tayari participants even after two years, or whether it was due to the limited nature of the Tayari intervention for those children who began PP2 in 2016, and would get less than one year of intervention total. Note that in 2017, all children in Kenya were benefiting from the PRIMR math program described above, by way of the PRIEDE national scale-up funded by the Global Partnership for Education, which also provided numeracy materials. It showed an impact of 0.2 *SD* or above on numeracy outcomes (Piper, Ralaingita et al., 2016). It may be that the equalized access to the PRIEDE numeracy program for both treatment and control schools in Grade 1 in 2017 was the cause of the washed-out numeracy effect from Tayari.

Our findings from the Combined classrooms gave us some clues as to how the fadeout effect occurred. There were statistically significant impacts of the Tayari numeracy index at the final assessment for children who began in the Combined classrooms in 2016, at 0.28 *SD* for the base and controlled regression models. Given that 36.6% of the children in Combined classrooms in 2016 still had not moved to Grade 1 in 2017, it appears that there were benefits of Tayari that required two years to enjoy. Future rounds of longitudinal data analysis on growth in numeracy skills in Tayari over time should help us to understand the Tayari effect more precisely.

Limitations

The Tayari longitudinal study was one of the largest ever to use randomization to form treatment groups and to examine learning outcomes in the preprimary education space available in the developing world. While the data are unique and the impact of Tayari appears to have been meaningful, the study suffered from several key limitations.

First, the overall Tayari research design included three treatment groups and a control group, whereas the Tayari longitudinal study included only one of those treatment groups and the control group. This means that the growth trajectories of children experiencing the other two Tayari treatment groups may differ from the pathways presented in this analysis and in the broader impact evaluation of Tayari. Fortunately, the external cross-sectional evaluation study examined the impact of all three treatment groups. The results suggested that the second treatment analyzed in the longitudinal study had the largest impact on school readiness, so this suggests that the results identified in the longitudinal study may be an upper bound of Tayari impact from the other treatment groups.

The Tayari program was designed to carefully improve learning outcomes of children in Kenya’s public and APBET schools in the four counties. The learning materials developed were structured to improve particular learning skills and create comfort with specific strategies for mathematics growth. The modified MELQO tool used for the external and longitudinal analyses was not precisely aligned with the particular instructional strategies of the Tayari intervention. As a result, there may be unidentified impacts of Tayari on numeracy that are meaningful for learners but were not assessed in the Tayari longitudinal study. For example, Tayari aimed to increase teachers’ and children’s confidence in doing mathematics, a change that is not easily measurable. On the other hand, the Tayari longitudinal study evaluated a broader range of numeracy assessments than did the overall impact evaluation.

The primary limitation of the study, from our point of view, was the behavior of the Tayari longitudinal assessment tool in general. We found that, at the final assessment in October 2017, many children were experience ceiling effects (Piper, Kwayumba et al., 2018). The tool’s lack of sensitivity made it more difficult to differentiate successful learners from struggling learners, and therefore to measure program impact, than we initially expected. Moreover, we found that some of the assumptions on the intra-class correlation of the Tayari learners were violated given this tool behavior.

The practical impact is that the tool was somewhat underpowered for the 0.2 *SD* effect that we designed it to identify. Table 3 above showed that the 0.29 *SD* impact of the Tayari program without controls was statistically significant only at the .07 level, when our assumptions were that we would be able to identify a 0.2 *SD* effect at the .05 level. The What Works Clearinghouse recommends that effect sizes of 0.25 *SD* be reported regardless of statistical significance (Institute of Education Sciences, US Department of Education, 2014). We addressed this limitation by including statistical models with control variables to increase precision. A simple model with two control variables (county and language spoken at home) increased precision enough to have the overall numeracy index to be found as statistically significant at the .03 level. Note that the inclusion of the control variables did not have a meaningful impact on the magnitude of the Tayari effect at either the index or the individual item level.

Conclusion

The Tayari preprimary program implemented in Kenya is one of the few medium-scale preprimary interventions in place that is testing the ability of approaches to improve school readiness if implemented at scale and through government systems. The advantage of this design is that the programs are more easily scaled up further, if successful, due to their having been tested in real-world conditions (Gove et al., 2017). Programs like Tayari may potentially trade larger statistical impacts on learning outcomes for real-world conditions, not only because the program works with whichever government officer is assigned to a particular geographic location—regardless of their skill level or work ethic—but also because the choice to randomize the treatment at the zonal level rather than the ECDE center level requires that the standard errors be clustered at the zonal level, which reduces the likelihood of seeing statistically significant impacts and expands the size of the sample needed.

Tayari's program improved the numeracy skills of children randomly assigned to ECDE centers supported by Tayari by 0.31 *SD* in the model with controls and 0.29 *SD* without controls. This effect was nearly the same as the overall Tayari effect identified in Piper, Kwayumba et al. (2018), which was 0.28 *SD,* with the literacy-specific gains at 0.31 *SD*. This effect falls in the range of the PRIMR early primary program results previously identified in Kenya, which had impacts on numeracy between 0.2 and 0.4 *SD,* and literacy impacts between 0.2 and 1.0 *SD*.

The results showed that the Tayari impact was larger for children who started in PP1 and were assessed at the end of the next academic year, when most of the children would have completed PP2, than it was for the children who started in PP2 and typically would have received only one year of Tayari intervention. For those children, the impact was 0.2 *SD* or less and was not statistically significant. The effect for the children who started in Combined classrooms was 0.28 *SD* in the model with controls, but 0.28 *SD* and not statistically significant in the model without controls. The Combined classrooms may have allowed students to work at their own level, and be exposed to content slightly above what they were able to do according to the Kenyan syllabus. The differentiation may have contributed to the slightly higher outcomes for these students. There appears to have been some noise in these estimates, and the basic finding was that Tayari's effect requires two years to be sustained. PP1 and PP2 activities for mathematics were closely aligned. For example, in PP1, a student may identify the number "6" and produce "6" objects. In PP2, students would identify "6," produce "6" objects, and then compare and contrast "6" to other numbers to build a flexible understanding of quantity. It may be that PP2 students who were not exposed to PP1 activities did not have enough of a base to fully engage in PP2 activities, or children needed two years' worth of exposure to similar activities. Future analyses should determine whether the

Tayari effect is able to resist a washout effect after those two years.

The PRIMR numeracy program's impact evaluation masked a differentiation in the types of numeracy tasks on which the program had an impact. PRIMR improved procedural tasks more than conceptual tasks. Responding to those disappointing findings on the impact on conceptual tasks, the Tayari intervention was designed to help young learners understand numeracy conceptually. Encouragingly, Tayari's impact was somewhat larger on the conceptual rather than procedural tasks. Tayari's extension will allow for a further data collection point of the longitudinal survey, which will allow us to continue to examine whether these impacts persist through primary school, when children will encounter the PRIEDE program; and whether the increased outcomes on the conceptual tasks persist.

Tayari's results over two academic years as measured on the numeracy tasks in this analysis showed that the Tayari intervention improved numeracy outcomes in statistically significant and conceptually meaningful ways. That these results were identified through a program that works within Kenyan government structures and using government personnel in a way that can be sustained is encouraging, as is the cost of less than US$15 per child per year accrued under the Tayari intervention (APHRC, 2018). Future analyses should examine whether and how these initial effects transition over time and whether the impacts of Tayari in numeracy have relationships with later outcomes and skills. In addition, we described the instructional strategies used in the Tayari program and highlighted the core principles upon which the program was developed. In doing so, we hope to encourage others to more fully describe their numeracy interventions in ECDE environments, instead of simply sharing results, to learn from others working to improve mathematical learning in sub-Saharan Africa.

Acknowledgement

The authors acknowledge the leadership of the Ministry of Education in Kenya, including the capable staff with expertise in early child development who led the technical implementation of Tayari, and the Kenyan teachers who implement in classrooms. In addition, we appreciate the generous funding of the Children's Investment Fund Foundation for Tayari implementation. Finally, we are thankful for Erin Newton's careful editorial contributions.

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ANNEX. TAYARI PRE-PRIMARY 2 LESSONS FROM WEEK 4

Week 4 Day 1

Week: 4	**Date:**
Objective:	By the end of the lesson, the learner should be able to: (i) Recognize the number symbols 1 to 10. (ii) Match numbers with corresponding number of objects (1–10).
Content:	Counting, number recognition, number value
Suggested resources:	10 counting objects for each group, number cards (1–10) for each group.
Suggested activities:	Singing, counting, number recognition game

Introduction

- Sing a number song.
- Rote count 1–20 using various actions.

Main Activity

Number recognition and matching

Whole class

Demonstrate the following activity:

- Put 10 objects/counters and a set of number cards 1 to 10, face down on the desk. Make sure the cards are not in order.
- Pick up a number card and ask or tell the learners the number on the card.
- Count the same number of objects as the number on the number card.
- Repeat the steps with the learners, using other number cards.

Small group

- Give small groups 10 objects/counters and a set of number cards 1 to 10.
- Guide learners to take turns picking up a number card, then counting the same number of objects as the number on the number card.

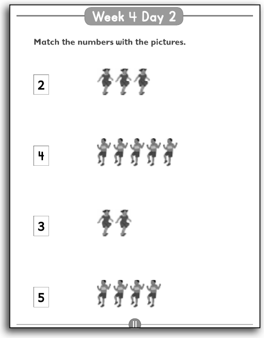
Conclusion

- Play a game where you write the numbers 4 and 8 on the board. Throw a ball or other object and hit one of the numbers. Tell learners to call out the number and show an equivalent number of fingers.

Remarks:

Week 4 Day 2

Week: 4	**Date:**
Objective:	By the end of the lesson, the learner should be able to: (i) Recognize the number symbols 1 to 10. (ii) Match numbers with corresponding number of objects (1–10).
Content:	Counting, number recognition, number value
Suggested resources:	10 counting objects for each group, number cards 1–10 for each group.
Suggested activities:	Singing, counting, number recognition game



Introduction

- Sing a number song.
- Rote count 1–20 using various actions.

Main Activity

Number recognition and matching

Whole class

Demonstrate the following activity:

- Put 10 objects/counters and a set of number cards 1 to 10, face down on the desk. Make sure cards are not in order.
- Pick up a number card and ask or tell the learners the number on the number card.
- Count the same number of objects as the number on the number card.
- Repeat the steps with learners, using other number cards.
- Pick up a number card and show the learners.
- Ask:
  - ❖ *Which number comes after the number I have?*
  - ❖ *Which number comes before the number I have?*
- Repeat the steps, using other number cards. Make sure you ask learners to say numbers that come after and those that come before the number you have chosen.

Small group

- Give each group 10 objects/counters and a set of number cards 1 to 10.
- Guide learners to take turns picking up a number card, then counting the same number of objects.
- Guide learners to match the numbers with the pictures in their workbooks.

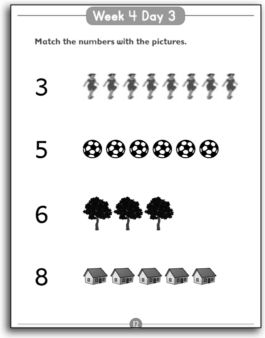
Conclusion

- Play a game where you write the numbers 7 and 10 on the board. Throw a ball or other object and hit one of the numbers. Tell learners to call out the number and show an equivalent number of fingers.

Remarks:

Week 4 Day 3

Week: 4	Date:
Objective:	By the end of the lesson, the learner should be able to (i) Recognize the number symbols 1 to 10. (ii) Match numbers with corresponding number of objects (1–10).
Content:	Counting, number recognition, number value
Suggested resources:	10 counting objects for each group, number cards (1–10) for each group
Suggested activities:	Singing, counting, number writing



Introduction

- Sing a number song.
- Rote count 1–20 using various actions.

Main Activity

Number recognition and matching

Whole class

Demonstrate the following activity:
- Put 10 objects/counters and a set of number cards 1 to 10, face down on the desk. Make sure cards are not in order.
- Pick up a number card and ask or tell the learners the number on the number card.
- Count the same number of objects as the number on the number card.
- Repeat the steps, using other number cards.

Small group
- Give small groups 10 objects/counters and a set of number cards 1 to 10.
- Guide learners to take turns picking up a number card, then counting the same number of objects as the number on the number card.
- Guide learners to match the numbers with the pictures in their workbooks.

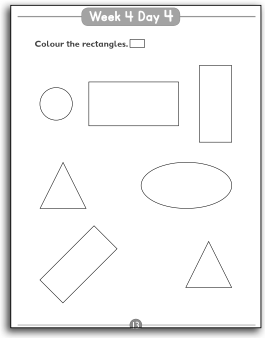
Conclusion

- Play a game where you write the numbers 6 and 9 on the board. Throw a ball or other object and hit one of the numbers. Tell learners to call out the number and show the an equivalent number of fingers.

Remarks:

Week 4 Day 4

Week: 4	Date:
Objective:	By the end of the lesson, the learner should be able to sort and group objects according to shape.
Content:	Sorting and grouping
Suggested resources:	Multiple objects of at least two different shapes (e.g. 6 triangles, 6 circles), items in the shop corner
Suggested activities:	Singing, telling daily routine, classifying objects



Introduction

Daily routine

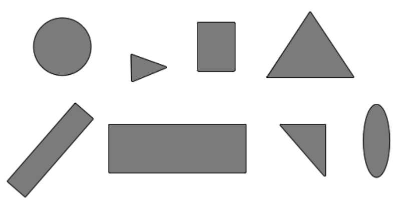
- Let some learners tell what they do during the school day (e.g. morning meeting, language activities, go outside).
- Guide learners to tell the order of these events from the first to the last.

Main Activity

Sorting and grouping

Whole class

- Identify shapes in the shop corner in the class.
- Show learners the different shapes of objects in the shop corner and state the shapes.
- *Draw the following shapes on the board.*



- Guide learners to circle all the triangles.
- Point to the three triangles and tell learners that even though they look different, they are all triangles.
- Emphasize that all triangles have 3 sides.
- Explain to the learners that we are going to make groups of similar shapes. Have learners help you to sort objects by shape.

Small group

- Provide objects of different shapes.
- Support each small group of learners to sort the objects according to shape.
- Guide learners to complete their workbook activity.

Suggested activities:

- If resources are available, provide enough objects to each group of learners to sort by shape during small group time.

Conclusion

- Have a few learners show how they sorted objects by shape.

Remarks:

Week 4 Day 5

Week: 4	**Date:**
Objective:	By the end of the lesson, the learner should be able to measure length between objects.
Content:	Measuring spaces between objects
Suggested resources:	Any object e.g. bags, shoes, desks, etc
Suggested activities:	Singing, counting, listening to a story, covering surfaces.

Introduction

- Sing a number song.
- Rote count 1–20 with various actions.

Main Activity

Measuring length

Whole class

- Put two objects (such as two bags, or two shoes) apart from each other.
- Ask:
  - ❖ *How can we measure how far apart the two objects are? (Use our feet, use our hands, strides).*
- Demonstrate how to measure the length between two objects using strides.

The image below shows how to measure length between spaces.

- Let the learners take turns practising how to measure the space between two objects.

Small group

- In small groups, guide learners to measure the length between two objects.

Conclusion

- Ask two learners to demonstrate how they measured the length between two objects.

Remarks: