
Lars-Erik Malmberg\textsuperscript{1}, Peter Mwaura\textsuperscript{2}, and Kathy Sylva\textsuperscript{1}
\textsuperscript{1} University of Oxford
\textsuperscript{2} Madrasa Regional Research Programme, East Africa, Kenya

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Please correspond with Lars-Erik Malmberg, Department of Education, University of Oxford, 15, Norham Gardens, OX2 6PY, Oxford, UK. e-mail: lars-erik.malmberg@education.ox.ac.uk.
Abstract

The aim of the study is to investigate the effects of the Madrasa Resource Centre (MRC), which is a child-centered intervention program on East-African (Kenya, Zanzibar and Uganda) preschool children’s cognitive development. Altogether 321 children (153 non-intervention and 168 intervention) participated in a cross-sequential study over three time-points during pre-school (mean ages 4.3, 6.0 and 7.1 years). A multilevel model (MLM; time-points nested within children nested within schools) in which time was coded flexibly (i.e., child’s age operationalized as months from start of the intervention), showed a beneficial curvilinear effect of the intervention program on children’s cognitive gains. A moderation analysis suggested that the effect of observed pre-school quality (ECERS) was stronger in the intervention program. The findings are discussed within the context of East-African pre-school policy.

[127 words]

Key words: cognitive development, East-Africa, intervention, child-centered pedagogy, Multilevel Model

Education in developing countries, and in East (sub-Saharan) Africa in particular, faces several challenges, such as insufficiently trained teachers, overcrowded classrooms, low levels of cognitive stimulation, and as a consequence, deteriorating educational outcomes, and a high level of dropout due to the lack of both material and human resources (Kholowa, & Rose, 2007; King, 2007). As in industrialized countries, the introduction of pre-school is seen as a way of improving educational equity, and when in parallel with other measures is a way of combating poverty and societal exclusion, promoting health care and advancing societal inclusion. As pre-school is a relatively recent phenomenon in East (sub-Saharan) Africa, it is important to know more about its potential benefits on children’s cognitive development. As a region, sub-Saharan Africa is among the most disadvantaged areas in the world, with poverty, malnutrition, short life-expectancy, high prevalence of diseases, high child mortality, and stunted child development (Alderman & Engle, in press; Grantham-McGregor et al., 2007; Iglesias & Shalala, 2002; Liddell, & Rae, 2001).

In a previous study we reported on the effects of the Madrasa Resource Center (MRC) child-centered intervention on cognitive development of pre-school children in disadvantaged Muslim communities in Kenya, Zanzibar and Uganda (Mwaura, Sylva, & Malmberg, 2008). To discern the intervention effect between onset, and half-way through pre-school, multiple regression models were carried out, using raw scores of school readiness outcomes, and controlling the effects of age and a range of covariates between
the start of preschool and halfway through the program (Mwaura et al., 2008). The findings showed that children in the MRC intervention had larger verbal, non-verbal and mathematical gains than in the comparison group, and both groups outperformed children who had stayed at home. In the present study we go beyond that study in three ways. First, the intervention effects up to the end of pre-school were investigated. Second, in order to increase precision of the cognitive measures, age-residualized scores were used in conjunction with a flexibly coded time-variable (coded as time elapsed from the first measurement). Third, we used a three-level multilevel model (MLM; time-points nested within children, nested within pre-schools) to account for differences in classroom practices across pre-schools.

**Stimulation of children’s cognitive development in pre-school**

Following models of Bronfenbrenner (1979; Bronfenbrenner & Morris, 1998), development is viewed as an interactive process between the individual and the environment. The influences vary as a function of the individual, the proximal environmental context (here the classroom in a pre-school setting), the more distal environmental context (here the policy context), and time (longitudinal follow-up from beginning to end of pre-school). In order to extrapolate how a pre-school intervention might be successful in stimulating children’s cognitive development in the East African context, we draw on a range of literatures: those on effects of health interventions, pre-school attendance and quality of pre-school on shorter and longer term academic outcomes (e.g., school readiness, literacy, numeracy), and equivalent studies in industrialized countries.

It is estimated that more than 200 million children in developing countries do not
reach their potential of cognitive development, due to lack of nutrition, early stimulation, or resources. While there is consistent evidence for the impact of health-intervention programs in raising children’s health status in developing countries (Grantham-McGregor et al, 2007), there is now a growing body of evidence regarding success of pre-school interventions on cognitive outcomes related to school readiness (Engle et al., 2007; Moore, Akhter & Aboud, 2008). Health interventions, which include child nutrition supplement, regular maternal health care checks, support, and inoculations, have been successful in reducing child mortality and diseases (Grantham-McGregor et al., 2007). These have indirect effects on child cognitive development through promotion of physical growth and brain development (Engle et al., 2007).

Results from pre-school interventions are in line with those from health interventions in developing countries, however effect sizes are smaller (Engle et al., 2007; Grantham-McGregor et al., 2007). Some observational studies of pre-school quality have been carried out in developing countries. For example, a study in Bangladesh (Moore, Akhter, & Aboud 2008) found that a higher level of observed pre-school quality predicted higher school readiness. In South Africa (Liddell & Rae, 2001) school readiness increased school performance, and decreased dropout rates, grade retention, and absence once in primary school. Mwaura et al (2008) found that children who had attended 18 months of pre-school had a higher level school readiness in verbal, non-verbal and numeric aspects of cognition, than children who had not attended pre-school, and those children who attended a child-centered intervention had a higher level of school readiness than those who attended state or Non-Government Organisation run pre-schools.

When effects of pre-school are found in developing countries, they are in line with
studies conducted in Western countries, where both childcare and pre-school quality have been predictive of children’s short-term or concurrent developmental outcomes (National Institute of Child Health and Development [NICHD], 2003a; Sammons et al., 2004), and longer term cognitive and social development reaching in to the primary school years (Belsky et al., 2007; Duncan et al., 2007; NICHD, 2003b). Studies in developed countries show consistent effects of pre-school structure and processes on cognitive and social developmental outcomes. Structural aspects such as the educational level or specialization of the staff (Arnett, 1989; Dowsett, Huston, Imes, & Gennetian, 2008), adult to child ratio (Pianta et al., 2005), type of pre-school (Sammons et al., 2003), and children’s access to and use of appropriate learning materials (Pianta, La Paro, Payne, Cox, & Bradley, 2002), have been found to promote children’s academic and social school readiness. In line with studies of the beneficial effects of parental sensitivity for child development (Ainsworth, 1973; Tamis-LeMonda, Shannon, Cabrera & Lamb, 2004), educational processes such as emotional support, warm and appropriate teacher-child interactions (Marjanovič Umek, Kranjc, Fekonja, & Bajk, 2007; Pianta et al., 2005), and the use of cognitive stimulation and sustained language interactions in the classroom (La Paro, Pianta, & Stuhlman, 2004; Pianta et al., 2002), have also been shown to be beneficial for children’s developmental outcomes.

Such process variables, usually termed global classroom quality, have shown stronger effects than structural variables (Howes et al., 2008). School readiness in pre-school is related to outcome assessments in Kindergarten and First grade in primary school, with a meta-analysis showing average cross-time relations of $r = .43$ in the cognitive domain and $r = .32$ in the social domain (La Paro & Pianta, 2000). There is also
some evidence that higher quality is more beneficial for disadvantaged than advantaged children (Burchinal, & Cryer, 2003), but there are also studies suggesting that all children, both those experiencing social risk and those who were not, benefited from higher quality child care (Burchinal, Peisner-Feinberg, Bryant, & Clifford, 2000).

Taken together there is some evidence in both developing and developed countries that attending pre-school itself is related to concurrent and later academic outcomes, that a higher classroom quality is related to higher concurrent and later academic outcomes, and that high quality pre-school can have a stronger effect on concurrent and later academic outcomes for more disadvantaged children. Given the severe challenges facing East African countries: poverty, ill health, and exclusion (Engle et al., 2007; Kholowa, & Rose, 2007; King, 2007; United Nations Educational, Scientific and Cultural Organization / Government of Kenya [UNSECO/GoK], 2005; United Nations International Children’s Emergency Fund [UNICEF], 2005), it would be important to know whether higher quality pre-school could contribute to alleviating these challenges.

The Madrasa Early Childhood Development Program

The Madrasa Early Childhood Development Program started with a request, made by Muslim communities in Mombasa, Kenya to His Highness the Aga Khan, to assist in improving educational standards and thereby providing opportunities for Muslim children in the area. The program took the traditional institution of education in Muslim societies, the Madrasa, and sought to revitalize it to provide appropriate and community-based pre-school education of high quality for Muslim children who were at the time among the most educationally disadvantaged and under-performing students in the country. In the
traditional Muslim system of education children were taught in a teacher-centered manner and the curriculum did not focus on secular knowledge and skills. As a result, children from the traditional Madrasa were rarely admitted to high performing primary schools. The Madrasa Resource Center (MRC) then developed a comprehensive approach to Early Childhood Education and Development (ECD), that created a high quality early learning environment and a curriculum in which religious and secular content was integrated with cultural and religious values in keeping with practices of the local communities.

In all three countries pre-school teachers need a minimum of eight years of schooling plus a one-year teacher training. Most preschool teachers are of secondary school level though some may not have finished all four years. Above this MRC teachers have their own initial training in the centers lasting six months leading to an ECD certificate. After graduation they continue to get post-graduation support as a form of professional development. In particular, the MRC staff are trained to use locally available low-cost materials for children to select, explore and experiment with, and to use language appropriate to stimulate children’s curiosity in a sensitive and supportive way (Aga Khan Development Network [AKDN], 2008). This teaching approach goes under the acronym MAMACHOLASU (MA: material; MA: manipulation; CHO: choice; LA: language and SU: support). The basic elements of the approach are in line with constructivistic theory about child development (Piaget, 1963; Vygotsky, 1978), and the active participatory learning curriculum of the High/Scope program (Schweinhart & Weikart, 1993). It is also in tune with research demonstrating beneficial effects of both material aspects (i.e., choice of materials to explore and manipulate) and process aspects (i.e., use of elaborate
language and provision of support) of early years education, which are crucial parts of the
promotion of pre-school children’s cognitive development (La Paro & Pianta, 2000;
Tonyan & Howes, 2003).

The intervention was initiated among disadvantaged, mainly but not exclusively,
Muslim families in East Africa, in order to make available culturally appropriate and
sustainable early childhood education. The program grew from a humble beginning, to its
current implementation of 203 pre-schools in Uganda, Kenya and Zanzibar, from which
close to 68,000 pre-school children have graduated and more than 6,000 teachers have
been trained at the time of writing (AKDN, 2008). As such, the intervention pre-school
staff differs from that of national pre-school staff, by attending continuing professional
development on the job, and receiving continuous support from local pre-school
management committees. The National ECD programs use the government designed
curriculum guidelines which emphasize the use of structured-play pedagogy to prepare
children for the formal learning in primary school. Using the National Guidelines, MRC
developed a curriculum that stresses active learning, religious integration and use of low
cost locally available materials. The MRC local school management committees oversee
the pre-school infrastructure development while the MRC staff supports the technical and
professional side. Among policy makers this program is regarded one of the most
efficient in East Africa (Mtahabwa, 2007). Although a number of qualitative case-studies
and evaluation reports of the MRC-program have been published (AKDN, 2008; Brown,
Brown, & Sumra, 1999; Downie, & Mwaura, 2010; Morgan & Muigai, 2000), the first
quantitative evidence was presented by Mwaura et al., (2008). As stated earlier the
present study goes beyond the Mwaura et al (2008) study by using new analytical tools and investigating the effects of the MRC up to the end of pre-school.

**Research questions**

(1) What is the effect of the Madrasa Resource Center (MRC) pre-school intervention program on children’s cognitive development?

(2) Is quality of pre-school related to cognitive development?

**Method**

**Sample** The data were collected using a cohort-sequential design in two cohorts of children, collected between 1999 to 2003 (cohort 1 from February, 1999 to November, 2001 and cohort 2 March, 2000 to February, 2003) in Uganda, Kenya and Zanzibar in 8 MRC centers, comprising 46 pre-schools at the first time-point, but dropping to 35 in the third time point. The first data collection took place in the first 3-4 months of the calendar year, and the second and third data collections during the last three months of the year.

In each country the comparison (non-Madrasa) pre-schools were selected among those pre-schools that were regarded normative within each geographical area. In Zanzibar (Revolutionary Government of Zanzibar, 2005) all the non-MRC pre-schools were government initiated and constructed, and attached to primary schools. Government prescribes the curriculum and its academic contents, and pays the teachers. In Kenya (Republic of Kenya, 2006) the non-MRC pre-schools were owned and managed the by the local communities. They employed government trained teachers, used a government prescribed curriculum. In Uganda (Republic of Uganda, 2007) the non-MRC pre-schools were owned and managed by a non-profit making organisation as an educational service for children in the community. As is the case with Kenya most of these centres are
initiated to prepare children for primary school. Pedagogical practice in non-MRC pre-schools in all three countries was relatively teacher-centered. In MRC pre-schools active learning methods are used and its curriculum integrates academic, secular and religious education elements. Children in all three countries attend preschool half a day for five days in a week. Children in non-MRC pre-schools typically changed teacher each year as they were grouped according to age in years. The MRC children were mixed across year-groups and attended classes with the same teacher.

These non-MRC schools were matched with MRC in each geographical area in terms of proportion of trained teachers, being physically located not more than three kilometers apart, and the pre-school having been operational for at least two years. Inspection of parental educational level and number of siblings, as proxies of disadvantage, suggested a tendency for intervention school parents to have slightly lower educational level than those in non-intervention schools ($t_{346} = 2.16; p < .05$), particularly in Kenya ($t_{117} = 2.62; p < .05$). There were no differences in number of siblings between the groups.

As the age of entry into pre-school varied between the three countries, classes of 3-year olds in Uganda and Kenya, and 4 year olds in Zanzibar, were enrolled in the first sweep of the study. Entry into pre-school reflected entry into primary school which is 7 in Zanzibar and 6 in Kenya and Uganda. In each class 10-12 children were randomly asked to participate, half boys and half girls. In the current study 321 children (144 boys and 177 girls) who were followed up two or three times, were included. There were 173 children followed up at all time-points (53.9 %), 142 children at Time 1 and 2 (44.2 %), and 6 children at Time 1 and 3 (1.9 %). The breakdown by country, cohort and time point is presented in Table 1. The children were on average 4.3 years ($SD = 0.85$) at Time 1,
6.0 (SD = 0.87) at Time 2, and 7.1 (SD = 0.87) at Time 3. Between one and 11 children per classroom per school were retained (M = 7.43; SD = 2.55) over time. The number of classrooms dropped from the initial 46, to 45 and 35 classrooms, the largest dropout in being in Uganda (see Table 1). The final study sample included 788 time-points nested within 321 children, nested within 46 schools, of which whom 153 were in the non-MRC and 168 in the MRC group.

Attrition analysis showed that children with higher cognitive scores at Time 1 were less likely to be followed up at Time 2 in Zanzibar (t(10.45 unequal variances) = 2.46; p < .05) and in Kenya (t(95) = 2.21; p < .05), but not in Uganda (t(80) = -0.96; p = .34). In contrast children with higher cognitive scores at Time 2 were less likely to be followed up at Time 3 in Uganda (t(67) = 4.06; p < .001), but not in Zanzibar (t(134) = -0.25; p = .81) or in Kenya (t(83) = -1.25; p = .21).

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**Cognitive skills.** The children were assessed through an adapted version of British Ability Scale II (BAS II; Elliot, Smith & McCulloch, 1996; Hill, 2005), and the African Child Intelligence Test (ACIT; Drenth et al., 1980), which is an adapted version of the Revised Amsterdamse Kinder Intelligentie Test (RAKIT; Bleichrodt, Drenth, Zaal & Resing, 1984, 1987). From the BAS three subtests were used: *block building* (16 items measuring visual-perceptual matching of spatial orientation in copying block patterns), *verbal comprehension* (40 items measuring receptive language in terms of understanding
of oral instructions involving basic language concepts), and *picture similarities* (33 items measuring non-verbal reasoning shown by matching pictures that have a common element or concept). In Western countries the BAS has good psychometric properties (Hill 2005), correlates well with the Wechsler Intelligence Scale for Children (WISC-III), and predicts school readiness and subsequent academic performance (Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggart, 2004).

From the African Child Intelligence Test (ACIT) three subscales were used (Drenth et al., 1980): *exclusion* (46 reasoning tasks in which the child chooses one abstract figure from a series of four that does not satisfy a rule that is common for the other three), *closure* (28 incomplete drawings from which the child recognizes what the incomplete object is), and *verbal meaning* (40 items for recognizing semantic units and behavioral situations, in which four different pictures are shown and the child chooses an object, animal, situation, or quality named by the test administrator). Adequate internal consistencies of these three subscales have been reported (Drenth et al., 1980), and the exclusion and closure subscales have been associated with improved iodine status and the Wechsler Preschool and Primary Scale of Intelligence (WPPSI; Van den Briel et al., 2000; see also Bleichrodt, 1999).

All instruments were extensively pre-tested for face validity within each context, and corroborated by local language experts. The tests were administered to children in their local native language individually by trained researchers (Swahili in Zanzibar and Kenya, and Luganda in Uganda). All children were given the same tests, thus using the assessments as criterion referenced tests, rather than norm referenced ones. Below we outline how we first calculated more precise estimates of each child’s chronological age.
at each time-point, by using information about the data-collection time-points. We then describe how we used that recoded age-information for residualizing the cognitive measures.

Table 2 here

Child’s chronological age. Children’s age was available in chronological years, but not months, at all or some of the three time-points of the study. As the date of each data collection time-point was recorded (see Table 2) we were able to derive a more detailed age-variable at each time-point, by adding the number of days elapsed between subsequent time-points to the chronological age at the first recorded instance. For example if a child was recorded to be 3 years old at Time 1, and 1 year and 112 days had elapsed between the first and second data point that child was recoded to be 4 years and 112 days, that is 4.31 years olds or 51.58 months old at the second time-point. When age was not recorded at the first time-point (e.g., possibly because the parents did not know, or did not regard it important; see also discussion about the role of age in African society) we used the data-collection time-point of the first recorded age to provide an estimate (in years and fractions of years) of the child’s age at prior data-collection time-points.

Age-residualized cognition scores. Given that we had information drawn from pre-school records of the child’s age in years for a standardization sample, we created age-standardized cognition scores in the total pooled sample of children who were tested once or more. We regressed the raw cognition score on child’s re-coded age (i.e., fractions of a year), and used the standardized residual (M = 0; SD = 1), for each cognitive measure
separately. This means that the age-effect on the cognition score has been partialed out, and hence not necessary to control for in the forthcoming models. Our method of using age-residualized scores was warranted, as other studies in East Africa have suggested that the Western age-scoring norm (e.g., T-scores, percentiles), might not be particularly valid, or that a direct translation of Western norms into African standards might be irrelevant (e.g., Berry, Poortinga, Segall, & Dasen, 1992; Van de Vijver, & Brouwers, 2009).

In a series of Confirmatory Factor Analyses in a standardization sample over three time-points, we tested whether a one-factor (general factor) or a two-factor solution (verbal versus non-verbal) would fit the data better (details are available from the first author at request). The models conducted with age-residualized scores fitted the data better than those conducted with raw scores. Although the one- or two-factor solutions fitted the data equally well, the correlation between the verbal and non-verbal factors was very strong, $\rho = .84$ at Time 1, and indistinguishable at Time 2 and 3 ($\rho$s = .98 and .99).

Given the strong correlations of the verbal and non-verbal components, we used the one-factor score as our outcome.

**Pre-school quality**

Pre-school quality was assessed using the revised version of the Early Childhood Environment Rating Scale (ECERS-R; Harms, Clifford, & Cryer, 1998; Perlman, Zellman, & Le, 2004), and the extension focusing on early childhood educational curriculum (ECERS-E; Sylva et al., 2006), which have been increasingly used outside Western countries (Hadeed & Sylva, 1999; Kwan & Sylva, 2001). Observed quality correlates with child outcomes (Peisner-Feinberg et al., 2001). Observers rated 61 aspects
of the environment (43 for ECERS-R and 18 for ECERS-E), on 7-point scales (1=inadequate, 3=minimal, 5=good, 7=excellent), with anchor-points specific to each rated aspect. In ECERS-R there are seven dimensions: space and furnishing (internal consistency in our study, Cronbach’s $\alpha = .82$), personal care routines ($\alpha = .80$); language reasoning ($\alpha = .82$); activities ($\alpha = .79$), interaction ($\alpha = .84$); program structure ($\alpha = .79$); parent and staff relations ($\alpha = .76$); while the ECERS-E is composed of four dimensions, namely literacy ($\alpha = .81$), mathematics ($\alpha = .73$), science and environment ($\alpha = .73$) and diversity ($\alpha = .57$). Observers were trained during live visits and reached acceptable inter-rater agreement with the gold standard on the third day of practice ($r = .74$ agreement). ECERS quality was higher in the intervention group than in the control group. The mean contrast effect sizes for ECERS quality between MRC and non-MRC pre-schools for the 11 observed quality measures over the three observation time-points, giving a grand average effect size of $d = .77$ ($d = 1.02$ at Time 1, $d = .50$ at Time 2, and $d = .80$ at Time 3).

**Analytic procedures**

We conducted a multilevel analysis in which we nested time-points (Level-1), within children (Level-2) and within classrooms / schools (Level-3) (Bryk & Raudenbush, 1992; Goldstein, 2003; Singer & Willett, 2003), in the MLWin software (Rasbash, Steele, Browne, & Goldstein, 2009). As the assessment points were unequally spaced, we created a time-scale which represented the timing of the data-collection, so that the first data-collection point for the first school was coded zero, and the two subsequent measurement points as years elapsed since that zero point in time (see Table 2). This allowed us to control for the time the child had spent in pre-school prior to the cognitive
assessment, and time elapsed between the data-collection points. As the MLM accommodates unbalanced designs (Singer & Willett, 2003), the analyses were conducted using all the available data for the longitudinal analysis. Inspection of such individual differences in change over time, and identifying predictors of change is an essential part of developmental research (e.g., Campbell, Pungello, Miller-Johnson, Burchinal, & Ramey, 2001).

**Multilevel models.** As the data were hierarchical, (time-points nested within children within schools), we carried out multilevel regression models in three levels: time at Level 1 (t), child at Level 2 (i), and school at Level 3 (j). Carrying out a multilevel model, rather than a model which does not distinguish between levels, allowed us, first, to avoid ecological fallacies (i.e., attributing the prediction of an outcome to the “wrong” level of analysis; Hox, 2002). Second, it enabled us to capture the complexity of real-world data including varying sample size that stems from attrition. Third, it appropriately allowed us to model the intervention effect as a school-level effect (Donner & Klar, 2000; Murray, 1998). We carried out the analyses in a series of logical steps (for details see the Appendix). First, an initial variance component model showed that 26%, 7% and 62% of the variance in cognition, were found respectively between schools, between children, and over time within children. A model in which we determined the shape of change over time by including a linear effect of time (i.e., “does change over time resemble a straight line?”) and a quadratic effect of time (i.e., “does change over time resemble a U-shaped, or inverted U-shaped trajectory?”), improved model fit ($\Delta LR = 134.77; p<.001$). A model which included two random terms to investigate whether there were differences between schools in the rate of change in cognition over time also
improved model fit. This model is shown as Model 1 in Table 3.

In Model 2 (Table 3) we included the fixed effects of child’s gender (0 = boy, 1 = girl), country (i.e., dummy-codes for Kenya and Uganda, using Zanzibar as baseline), country × time (i.e., whether linear changes over time differed between the three countries), and a country × time-square (i.e., whether quadratic changes over time differed between the countries), with the random effects as above. In Model 3 we included the fixed effects of the MRC-intervention (i.e., whether non-MRC and MRC groups differed at the zero point in time), MRC × time and MRC × time-square (i.e., the extent to which the children in the intervention group had a more accelerated change in cognition over time than in the non-intervention group). In Model 4 we entered total ECERS score calculated as the average of the ECERS-R (global quality) and ECERS-E (curriculum quality), given that the R and E versions were strongly correlated at each time-point (Time 1 r = .77 [43]; p<.001, Time 2 r = .62 [43] p<.001, and at Time 3 r = .85 [43], p<.001), and supplementary analysis showed no difference in fixed effects between using the total ECERS, or the E or R versions separately. The total ECERS score was entered as a time-varying covariate as most of the children changed teacher as they moved from one younger age-group within each pre-school from one year to the next. In Model 5 we included an MRC × ECERS effect, for inspecting whether the effect of pre-school quality on cognition was stronger in either pre-school type.

Results

In Model 1 (Table 3) the fixed effect of linear time showed that children, on average, increased in cognitive skill around half a standard deviation per year ($B = .53$; $p <.001$),
but the trend was inversely U-shaped ($B = -.11; p < .001$) peaking around the time of the second measurement and then declined. The random effect of time at the school level showed that pre-school classes differed in their trajectories across time ($\sigma^2_{v1} = .05; p < .001$), and pre-school classrooms with a high average cognitive level at onset changed slightly less over time ($\sigma_{v01} = -.08; p < .01$). This latter covariance can be indicative of a mastery effect, meaning that children starting off a lower level increase more over time.

In Model 2 we observed the fixed effects of child’s gender, and a series of country effects (2 dummy codes), and interaction effects between country and time. No gender difference was found. Ugandan children increased more rapidly over time ($B = .81; p < .001$), and also exhibited more of an inverted U-shaped change ($B = -.25; p < .001$) than children in Zanzibar.

In Model 3 the intervention effects showed that the MRC and non-MRC groups did not differ at onset of pre-school (i.e., when time was coded zero; $B = .03; p = \text{n.s.}$). The intervention $\times$ time effect showed that children in the MRC schools increased their cognitive level .40 standard deviations per year more than children in the non-MRC schools did ($B = .40; p < .01$). However, the intervention $\times$ time-square effect was significant ($B = -.16; p < .01$). As shown in Figure 1 (to the right) the change over time in the MRC-group had the shape of an inverted U-shape, showing the intervention effect more accentuated around the second time-point but not accelerating as fast towards the end of the study. The Time 2 mean contrast effect size was $d = .48$, and at Time 3, $d = .32$. The correlation between Time 1 and 2 was $r = .31$ and between Time 2 and 3 $r = .51$.

In Model 4 we included the main fixed effect of time-varying ECERS quality which significantly predicted cognitive skills ($B = .15; p < .001$). Importantly the intervention $\times$
time and intervention × time-square effects remained significant. This suggested that a higher pre-school quality predicted a higher cognitive outcome independent of the intervention effect. In Model 5 the included ECERS × intervention effect was significant ($B = .20; p < .001$), while the main ECERS effects turned non-significant, suggesting that quality predicted cognition differently in the two pre-school types. We carried out follow-up analyses separately in the non-MRC and MRC groups (see the Appendix). We first included fixed effects of gender, country, country × time, and country × time-square, and random effects as in Model 1. In a second step we added the time-varying ECERS. This analysis showed that ECERS was not a significant predictor of cognitive outcome in the non-MRC group ($B = .02; \Delta LR = 0.17; p = .67$), while it in the MRC-group had a significant effect ($B = .23; p < .001; \Delta LR = 40.8; p < .001$).

Table 3 here

Discussion

The aim of the present study was to investigate the effects of the Madrasa Resource Center (MRC) program on cognitive development of pre-school children across the beginning, middle and end of pre-school, using age-residualized scores and flexible time-coding, in a three-level model. The findings expand upon previous evidence of beneficial effects of the MRC program in general (Brown et al., 1999), and between the beginning and the middle of pre-school (Mwaura et al., 2008), and up to the end of pre-school. We compare the findings against those in Western countries, and discuss the role of the
findings within the context of East African child care, education, and policy, and the challenges it is facing.

**Effects of the MRC-program on child cognitive development**

When the findings in the present study were compared with those from the Mwaura et al (2008) study, three noteworthy findings were observed. First, we found that models in which both linear and quadratic effects of time on cognition fitted the data well. Second, we found differences between the countries with regard to the linear and quadratic effects of time on cognition. Third, the effect of classroom quality was stronger in the MRC than in the non-MRC group.

Our findings were clearly in line with the Mwaura et al (2008) study, in which larger increases in verbal, non-verbal and numeric cognitive school readiness between onset and halfway through pre-school (i.e., the first and second time-points) for MRC-children than for non-MRC children. In the present study, when investigating whether this trend continued up to the end of pre-school, we found both a positive linear effect ($B = .53$), and a negative quadratic effect which was stronger in the MRC than in the non-MRC group ($B = -.11$). There are at least three ways to interpret the quadratic trend (i.e., an inverted U-shaped trend). Either it suggests a diminishing return of the intervention between the second and third time-point, meaning that the intervention may work well for younger children, but not for older pre-school children. The second interpretation is similar to that in the Abecedarian study of early intervention effects among children from families living in poverty (Campbell & Ramey, 1994). They also found larger cognitive gains earlier on in the intervention suggesting that young children can blossom when they are given an enhanced opportunity to learn new things, a process that slows somewhat,
even if the enriched environment is still there. The third interpretation is related to country-specific patterns of attendance in the MRC pre-schools.

**Country-specific patterns of cognitive growth** The magnitude of the linear and quadratic change over time was stronger in Uganda than elsewhere. Ugandan children started off lower, accelerated more rapidly, and attrition between the second and third time-points was markedly larger than in Zanzibar and Kenya. A plausible explanation for the Ugandan attrition is mass-migration from pre-school into primary school. This means that parents seek good quality pre-schools for their children, in order for them to gain access to prestigious or high-quality primary schools. As it was the Ugandan children with a higher (not lower) cognitive level that left the pre-schools suggests that this could be the case.

At a more general level however, delayed entry into primary school (range 5.5 - 8.9 years at the third time point; see Table 2) is quite common in the East African context. One reason for the delay can be that parents lack funds for paying school fees, particularly for schools which have a reputation of being of higher quality, and might save money for sending the child to the desired school later. Another reason is that chronological age is not regarded an important marker or a person’s status in indigenous African culture (Berry et al., 1992). Other markers play an important role, such as social age (e.g., entry into manhood or womanhood for adolescents and wisdom attributed to old age), and concepts of ability (Grigorenko et al., 2001; Malmberg, Wanner, Sumra, & Little, 2001). Parental perception of their child’s cognitive ability might well have contributed to children leaving pre-school and entering primary school at a relatively younger age among the children in our Ugandan sample, and delayed entry for children
who were perceived to be less developmentally adept.

**Effect of classroom quality** Including the observed global classroom quality as a predictor appeared to enhance the beneficial effect on cognitive development. Particularly we found evidence for a moderation effect, in which school type moderated the relationship between pre-school quality and cognitive level ($B = .02$ versus $B = .23$). As the ECERS observation instrument captures the essential aspects of the intervention strategies (the use and choice of locally available materials for children to explore and experiment with under the guidance of warm and stimulating personnel), the effect of the intervention suggests that personnel training in the particular intervention method (Burchinal, Campbell, Bryant, Wasik, & Ramey, 1997; Howes et al., 2008), is observable in the teacher-child interaction, which in turn relates to a higher observed classroom quality, and positive effects on children’s cognitive developmental level. Demonstrating the effect pre-school intervention up to the end of pre-school, bodes well for children’s entry into primary school. Demonstrating that positive effects of teacher’s having had the MRC preschool training can be detected across all three years of pre-school bodes well for children's entry into primary school. As school readiness in pre-school, has been found to relate to concurrent outcomes (NICHD, 2003a), and primary school performance (La Paro & Pianta, 2000), future studies in the sub-Saharan context would benefit from following children up into primary school and beyond. Such a follow-up could reveal whether continued positive teacher-student interaction is related to students’ academic and behavioral outcomes (Belsky et al., 2007; Hattie & Timperley, 2007; NICHD, 2003b).

The findings presented here are encouraging when considering the context in which
they appear, for three reasons. First, the structural effect of attending the intervention pre-
schools, in which the personnel had been trained to use locally available (low-cost) 
materials within a child-centered program, had a beneficial curvi-linear effect on 
children’s cognitive development as compared to children who attended the comparison 
(state or NGO-run) pre-schools. Even though this demonstrates that the intervention need 
not be costly in terms of materials, the bulk of the resources nevertheless went into the 
training, monitoring and support of the intervention personnel. Future studies need to 
explore how the sensitive use of low-cost materials can be implemented more broadly 
among parents and older siblings, and teachers in primary school.

**Pre-school and schooling in East-Africa**

National policies in East Africa have followed the Millennium Developmental Goals 
(MDG), for combating poverty and exclusion, and improving health care and education. 
Although pre-schools in Zanzibar, Kenya, and Uganda are seen as a vehicles for 
improving educational quality at the individual level and equity at the societal level 
(Revolutionary Government of Zanzibar, 2005; Republic of Kenya, 2006; Republic of 
Uganda, 2007), it remains difficult to disentangle the effects of pre-school participation in 
improving social and economic standards and also to predict future longer-term 
contribution of pre-school participation to these agendas.

The problem in evaluating the distinctive past and future contribution of pre-school 
education seems to be twofold: on the one hand governments appear to know less about 
the state-of-affairs in pre-schools in their countries, than they do about primary and 
secondary schools. One the other, access to pre-school education is generally not 
widespread or equally distributed geographically with rural areas being particularly
deprived. Other structural issues include reducing adult-to-child ratios (Mtahabwa, 2007), and increasing the number of trained pre-school teachers who adhere to developmentally appropriate curricula (Kholowa & Rose, 2007).

If governments want to improve the overall equity of the educational system (i.e., equality of access to, output from and outcomes of education), some authors pose that sector-wide, multi-sector and multi agency approaches are necessary for the improvement of educational systems and their contribution to social equity and well-being of the population (King, 2007; Nishimura, Engle et al. (2007), Yamano & Sasaoka, 2008).

Engle and colleagues (2007) point out to a specific issue of governance and regulation of the pre-school sector. They indicate that in several countries no single authority appears responsible for drawing up and implementing health, social and educational guidelines for the pre-school period. Hence multi-agency interventions are necessary and also appear to be the most effective in encouraging children’s physical, cognitive and social development. In the light of this, government agencies need to collaborate with each other, and direct monetary and personnel resources in the area of child development, particularly pre-school education, but also for the transition from pre-school into primary school (Engle et al., 2007).

**Limitations**

There were three obvious limitations to the present study. First, detailed information about children’s chronological age was not collected. We attempted to address this issue by using age-residualized cognition scores together with a flexible time-coding, enabling increased precision in the modeling when detailed child
chronological age-information was not available. Second, the attrition was complex and in some instances systematic. We did not attempt imputation of missing data at the third time-point as there was some evidence that the children had exited the pre-school to enter primary school (particularly in Uganda). Instead we did not consider the attrition to pose a threat to the models as the MLM handles unbalanced designs well. Third, the researchers who administrated the cognitive tests and observed classroom quality were the same. However, the researchers were external to MRC-staff, and trained to treat the schools and children equally. In most cases the researchers first assessed cognitive abilities of each child and then observed the child care quality of the pre-school. This could have introduced bias in the observation scores in favor of the MRC pre-schools.

**Conclusion**

The aim of the study was to investigate the effects of the Madrasa Recourse Centre (MRC) child-centered constructivistic intervention program on pre-school children’s cognitive development in East Africa. Intervention and comparison children participated in a cross-sequential study over three time-points from the beginning to the end of pre-school. A multilevel model in which time was coded flexibly (i.e., child’s age operationalized as months from start of the intervention), showed a beneficial effect of the intervention program on children’s cognitive development. Our moderation analysis showed that observed quality predicted children’s cognitive outcome in the intervention, but not in the comparison pre-schools. Seen within a distal context of environmental risk (e.g., poverty or illness), the findings are in line with studies showing increased benefits of warm, sensitive and stimulating adult-child interaction in a pre-school context.
conducive to child development. We hope that these findings can encourage the promotion of pre-school interventions by governments, NGOs and donors to alleviate the effects of such enduring risk factors on early child development.
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Table captions

Table 1.
Study participants by time-point, country, gender, and intervention at individual level (above) and school level (below).

Table 2.
Participants’ age, residualized cognition score and data collection month since start, by time-point, country, and intervention.

Table 3.
Three-level models of pre-school intervention

Figure caption

Figure 1.
Estimated school level trajectories (thinner lines) of age-residualized cognition scores over time (time in years from onset of pre-school-year on x-axis) for non-Madrasa Resource Centre (non-MRC) children (left) and Madrasa Resource Centre (MRC) children (right). The group-level trajectory is superimposed in thick line.
Table 1: Study participants by time-point, country, gender, and intervention at individual level (above) and school level (below).

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Table 2: Participants’ age, residualized cognition score and data collection month since start, by time-point, country, and intervention.

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<td>All MRC</td>
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Note: \(^a\) = in a standardization sample (available on request), the cognition scores were regressed on chronological age corrected for
data collection time-point, the standardized residuals outputted and averaged into a total cognition score. \(^b\) = years elapsed since start
of pre-school year (January) when data collection began. \(^c\) = average of observer reports of the original Childhood Environment Rating
Scale (ECERS-R; Harms, Clifford, & Cryer, 1998), and the extension focusing on curriculum quality (ECERS-E; Sylva et al., 2006).
Table 3: Three-level models of pre-school intervention

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<th>p</th>
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<th>p</th>
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Random effects

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Model fit

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Note: Estimates are from MLwin 2.10 (Rasbach et al., 2009), using the Restricted Maximum Likelihood (REML) Estimator. Significance tests are Wald estimates. For the random effects the Wald tests should be regarded as indicative only (Berkhof & Snijders, 2001).
Figure 1. Estimated school level trajectories (thinner lines) of age-residualized cognition scores over time (time in years from onset of pre-school-year on x-axis) for non-Madrasa Resource Centre (non-MRC) children (left) and Madrasa Resource Centre (MRC) children (right). The group-level trajectory is superimposed in thick line.
Appendix

First, we conducted a variance component model (Equation 1), in which $cogn_{ij}$ is the dependent variable cognition measured at three time-points, with $t$ indicating the lowest level time, $i$ the individual level and $j$ the classroom level. $\beta_0$ is the grand weighted average of cognition. The variance of cognition is decomposed into proportions between schools (26%), between children (7%), and within children (62%) as shown in Equation 2:

$$cogn_{ij} = \beta_0$$

(1)

with the random terms

$$\beta_0 = \gamma_0 + \nu_{0i} + \nu_{0ij} + \epsilon_{0tij},$$

(2)

in which all variance terms $\nu_{0i}$ (deviance of pre-school from $\beta_0$), $\nu_{0ij}$ (deviance of child from pre-school classroom average), $\epsilon_{0tij}$ (deviance of time-point from child’s average cognition), are normally distributed $\sim N(0, \Omega_\gamma)$, $\sim N(0, \Omega_\nu)$, and $\sim N(0, \Omega_\epsilon)$.

In the next step we assessed the shape of change over time by including a linear effect of time ("does change over time resemble a straight line?") and a quadratic effect ("does change over time resemble a U-shaped, or inverted U-shaped trajectory?"), as shown algebraically in Equation 3, in which $\beta_1$ and $\beta_2$ are the fixed effects of linear and quadratic time (i.e., increase in cognition for each unit increase in time, here scaled to years). Random effects were estimated as in Equation 2.
cognitive = \beta_{0ij} + \beta_{1ij}time_{ij} + \beta_{2ij}time-square_{ij} \quad (3)

Including these fixed effects changed the variance components to 37%, 13% and 50% at the school, child and time levels respectively, demonstrating that including the effects of time explained a lot of the time-level variance (Hox, 2002).

Next we in Equation 4 estimated whether schools differed in change over time by including the random effect of time at the school level (\nu_{ij} time/time, \sigma_{\nu 1}^2), which also allowed us to inspect whether onset in school level cognition was related to change in school level cognition (school/time covariance, \sigma_{\nu 01}). This model is included as Model 1 in Table 3.

\beta_{0} = \gamma_{0} + \nu_{0ij} + \epsilon_{0ij},
\beta_{1j} = \gamma_{1} + \nu_{ij} \quad (4)

where

\begin{bmatrix}
\nu_{0k} \\
\nu_{1k}
\end{bmatrix} \sim N(0, \Omega_{\nu}): \Omega_{\nu} = \begin{bmatrix}
\sigma_{\nu 0}^2 \\
\sigma_{\nu 01} \\
\sigma_{\nu 1}^2
\end{bmatrix}

Next we (Equation 5; Model 2 in Table 3) included fixed effects of child’s gender (0 = boy, 1 = girl), country (dummy-codes for Kenya and Uganda, using Zanzibar as baseline), country \times time (for picking up whether linear changes over time differed between the three countries), and a country \times time-square (for picking up whether quadratic changes over time differed between the countries),
cogn\textsubscript{ij} = \beta_0 + \beta_1 \text{time}_{ij} + \beta_2 \text{time-square}_{ij} + \beta_3 \text{gender}_{ij} + \beta_3 \text{Kenya}_j + \beta_4 \text{Uganda}_j + \beta_5 \text{Kenya}_j \times \text{time}_{ij} + \beta_6 \text{Uganda}_j \times \text{time}_{ij} + \beta_7 \text{Kenya}_j \times \text{time-sq}_{ij} + \beta_8 \text{Uganda}_j \times \text{time-sq}_{ij} + \beta_9 MRC_j + \beta_{10} MRC_j \times \text{time}_{ij} + \beta_{11} MRC_j \times \text{time-sq}_{ij} \quad (5) \\

\text{cogn}_{ij} = \beta_0 + \beta_1 \text{time}_{ij} + \beta_2 \text{time-square}_{ij} + \beta_3 \text{gender}_{ij} + \beta_3 \text{Kenya}_j + \beta_4 \text{Uganda}_j + \beta_5 \text{Kenya}_j \times \text{time}_{ij} + \beta_6 \text{Uganda}_j \times \text{time}_{ij} + \beta_7 \text{Kenya}_j \times \text{time-sq}_{ij} + \beta_8 \text{Uganda}_j \times \text{time-sq}_{ij} + \beta_{10} \text{ECERS}_{ij} + \beta_{10} \text{MRC}_j \times \text{ECERS}_{ij} \quad (6) \\

\text{cogn}_{ij} = \beta_0 + \beta_1 \text{time}_{ij} + \beta_2 \text{time-square}_{ij} + \beta_3 \text{gender}_{ij} + \beta_3 \text{Kenya}_j + \beta_4 \text{Uganda}_j + \beta_5 \text{Kenya}_j \times \text{time}_{ij} + \beta_6 \text{Uganda}_j \times \text{time}_{ij} + \beta_7 \text{Kenya}_j \times \text{time-sq}_{ij} + \beta_8 \text{Uganda}_j \times \text{time-sq}_{ij} + \beta_{10} \text{MRC}_j \times \text{ECERS}_{ij} \quad (7)

Please note that the random effects are as Equation 4.

Then we in Equation 6 (Model 3 in Table 3) included the fixed effect the MRC-intervention (i.e., whether non-MRC and MRC groups differed at the zero point in time), MRC \times \text{time and MRC \times time-square} (for picking up the extent to which the children in the intervention group had a more accelerated change in cognition over time than in the non-intervention group).

We then in Model 4 in Table 3, added the total time-varying ECERS score \beta_{12} \text{ECERS}_{ij}, and in Model 5 the interaction effect between ECERS and the intervention \beta_{13} MRC_j \times \text{ECERS}_{ij}.

We tested whether the suggested moderation effect would distinguish differences in school-type quality effects on cognitive outcomes, by regressing cognition in each school-type group (MRC versus non-MRC) separately (Equation 7):
cogn_{ij} = \beta_0 + \beta_1 \text{time}_{ij} + \beta_2 \text{time-square}_{ij} + \beta_3 \text{gender}_{ij} + \beta_3 \text{Kenya}_{j} + \beta_4 \text{Uganda}_{j} \quad (7)
+ \beta_5 \text{Kenya}_{j} \times \text{time}_{ij} + \beta_6 \text{Uganda}_{j} \times \text{time}_{ij} + \beta_7 \text{Kenya}_{j} \times \text{time-square}_{ij} + \beta_8 \text{Uganda}_{j} \times \text{time-square}_{ij}

with random effects as Equation 4.

In the next step \beta_9 \text{ECERS}_{ij} was added.