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Quality and Inequality in Pre-Primary and Home Environment Inputs to Early Childhood Development in Egypt

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Abstract

By the time children in low- and middle-income countries start primary school, large socioeconomic disparities are evident in children's learning and development. Both pre-primary and home environments can play important roles in influencing school readiness and can contribute to disparities in early childhood development, but there is limited evidence on their relative roles in low- and middle-income countries. This paper examines how pre-primary quality, stimulation at home, and early childhood development vary by socioeconomic status for pre-primary students in the Arab Republic of Egypt. The results demonstrate substantial socioeconomic inequality in stimulation at home, more so than in pre-primary quality and inputs, although there is variation in the degree of inequality across different dimensions of pre-primary quality. "Double inequality" is observed, where students with less stimulating home environments experience slightly lower quality pre-primary inputs. There are particularly large pre-primary inequities in structural quality (physical environment) and less inequity in process quality (pedagogy). These results suggest that targeted investments in pre-primary education in Egypt are necessary to reduce inequality in school readiness but are likely insufficient to close the socioeconomic status gap in children's development. Investing in interventions to improve vulnerable children's home learning environments, as well as investing in quality pre-primary, is critical to address disparities in children's development.

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1 Introduction

Education systems in low- and middle-income countries (LMICs) struggle with a learning crisis. While school enrollments have expanded, learning and even basic skills such as literacy lag for children in LMICs compared to high-income countries (HICs) (Le Nestour, Moscoviz, & Sandefur, 2022; World Bank, 2018). A key reason that children in LMICs fall behind is under-investment in early childhood development (ECD), generally, and pre-primary education specifically (Nores & Barnett, 2010; World Bank, 2018).

Millions of children are at risk for low-quality care in the early childhood years (McCoy, Seiden, Cuartas, Pisani, & Waldman, 2022). Additionally, substantial disparities in stimulating home environments and access to pre-primary across and within LMICs have been documented (Krafft & El-Kogali, 2021; McCoy et al., 2018). While there is a large literature documenting inequality in ECD and home environments in both HICs and LMICs (Flood, McMurry, Sojourner, & Wiswall, 2022; Walker et al., 2011), and research exists on unequal pre-primary quality in HICs (Flood, McMurry, Sojourner, & Wiswall, 2022), less is known about inequities in access to quality pre-primary learning environments in LMICs.

Pre-primary education can particularly benefit disadvantaged children (Holla, Bendini, Dinarte, & Trako, 2021) by reducing gaps in learning and development that form before the start of formal schooling. The recent push to increase pre-primary enrollments in LMICs recognizes the importance of the quality of pre-primary programs (Bendini & Devercelli, 2022). However, there is little research on whether the disadvantaged children who do attend pre-primary in LMICs have equal access to quality pre-primary environments. Inequality in pre-primary quality could be more, less, or similar to inequalities in home environment quality in LMICs. The relative degree of inequality in home and pre-primary environments has important implications for the potential of pre-primary to reduce, maintain, or exacerbate school readiness gaps for disadvantaged children.

This study uses data from kindergartens (KGs) and KG students in the Arab Republic of Egypt to investigate quality and inequality in both pre-primary and home environments – the two central drivers of ECD for pre-primary students. It is particularly unusual to have data on both pre-primary quality and home environments in LMICs, to be able to examine inequality as well as potential complementarities or substitutions between these important inputs. Egypt is a valuable setting to be able to assess this inequality; the country has relatively low pre-primary enrollments compared to other countries at similar levels of development (El-Kogali & Krafft, 2015). Pre-primary is also the phase of education in Egypt with the largest socio-economic inequality (Krafft & El-Kogali, 2021).

Based on existing literature, we hypothesized that disparities in the quality of learning environments (at home and in pre-primary settings) and disparities in children's developmental outcomes would be evident in Egypt, as they are in other countries. We specifically examine, for Egyptian pre-primary students, how pre-primary quality, stimulation at home, and early childhood development outcomes vary by socio-economic status (SES). We further explore which aspects of pre-primary quality (such as the physical environment or pedagogy) are more equitable. Due to lack of research on young children in Egypt, we had no specific hypotheses on whether disparities would be larger in home or pre-primary learning environment, nor did we hypothesize on the

relative contributions of each to young children's developmental outcomes. We undertake these analyses using factor analysis to generate measures of ECD, dimensions of pre-primary quality, and stimulation at home. We then use regression models for how these outcomes relate to SES.

The results demonstrate that pre-primary students face substantial socio-economic inequality in stimulation at home, more so than in pre-primary quality and inputs. We find, for example, that pre-primary students with mothers with no education experience an average of 0.84 standard deviations lower level of stimulation at home than children of university-educated mothers. Inequality in students' experiences of quality pre-primary education varies substantially by the dimension of quality in question; we document the largest inequities in structural quality (physical pre-primary environment) and less inequity in process quality (teacher practices, children's experience of quality materials and adherence to the curriculum). These results suggest that pre-primary classrooms may provide relatively more equal opportunities for children to learn, and thus may have an important role to play in reducing the school readiness SES gap. At the same time, the importance of the home learning environment in shaping developmental outcomes, which varies substantially by SES, is profound. Very high-quality learning environments are likely required for the most disadvantaged children to begin to address the gaps in learning that are evident in pre-primary due to home learning environments. Yet, even the highest quality pre-primary learning environment may be insufficient to address disparities in early development, indicating the need to address inequalities in home environments as well.

2 Background

2.1 Evidence on inequality in early childhood development

Data from across the globe emphasize important gaps in development that start in early childhood and persist thereafter (Britto et al., 2017; McCoy, Seiden, Cuartas, Pisani, & Waldman, 2022). For instance, at age five, children in Peru, Ethiopia, India, and Vietnam all already had large socio-economic gaps in their vocabulary (Lopez Boo, 2016). Some evidence suggests that disparities in early cognitive development emerge within the first year of life (Fernald, Kariger, Hidrobo, & Gertler, 2012). Across Cambodia, Mongolia, and Vanuatu, there were significant SES gradients in language, literacy, mathematics, and executive function of children aged 3-5 years, with pre-primary attendance mediating some of the disparities (Sun, Zhang, Chen, Lau, & Rao, 2018). Both home and pre-primary environments can play an important role in ECD and early inequality.

2.2 Evidence on the importance of a stimulating home environment

In LMICs, both nutrition and responsive caregiving (a stimulating home environment) have been shown to be critically important to children's subsequent development in the first years of life (Britto et al., 2017; Gertler et al., 2014). A substantial body of research from LMICs documents the importance of parenting for children's development in early childhood, both concurrently and longitudinally (Knauer, Ozer, Dow, & Fernald, 2019; Lu et al., 2020). Programs promoting improvements in parenting can change behaviors in ways that improve children's development, although not necessarily all dimensions of development (Premand & Barry, 2020). Early childhood interventions with an educational or stimulation component had the largest cognitive effects in a review of the international literature (Nores & Barnett, 2010).

However, children do not have equal access to stimulating home environments, contributing to inequality in ECD and continuing throughout childhood and adolescence. For example, in Brazil and South Africa, children with higher-quality home learning environments during the pre-primary years had higher IQs and greater psychosocial adjustment as young adults (Trude et al., 2021). These early inequities in stimulating home environments arise from a number of environmental influences, starting at preconception and extending throughout early childhood, including lack of access to adequate health care and nutrition; lack of social protection; and poverty (Britto et al., 2017). Early gaps between children with supportive environments and those with less supportive environments persist over time, leading to substantial inequities at the start of formal schooling that persist throughout childhood (Crosnoe, Leventhal, Wirth, Pierce, & Pianta, 2010) and may even fully account for SES-related group differences in early developmental outcomes (Rosen et al., 2020).

2.3 Evidence on the importance of quality pre-primary teaching and learning

Inequality in pre-primary education starts with whether children are able to attend pre-primary at all. Family wealth and maternal education have been shown to have a powerful influence on whether young children access early childhood education (Rao, Cohrssen, Sun, Su, & Perlman, 2021), compounding the impact of home environments. Higher-income and more educated parents are more likely to ensure their children attend high quality early childhood settings, which in turn leads to compounding disparities as children with more home stimulation are also more likely to have stimulating out-of-home learning environments (Alexandersen, Zachrisson, Wilhelmsen, Wang, & Brandlistuen, 2021; Meyers & Jordan, 2006; Rao, Cohrssen, Sun, Su, & Perlman, 2021).

Even when children are able to attend pre-primary education, existing research suggests that high-quality[5] pre-primary settings may be relatively rare within LMICs. While there are few sources of descriptive data on pre-primary classrooms in LMICs, research suggests that classrooms may lack child-centered approaches and access to materials that promote children's learning, with high reliance on rote instruction of early academic skills and unsafe physical conditions (Bidwell & Watine, 2014; Raikes, Koziol, Davis, & Burton, 2020). While early childhood care and education can have a positive impact on school readiness and reduce inequality (Jung & Hasan, 2014; Krafft, 2015; Nores & Barnett, 2010; Nores, Bernal, & Barnett, 2019), in some studies, attending low-quality pre-primary led to no or negative effects on children's development compared to alternative care or schooling arrangements (Blimpo, Carneiro, Jervis, & Pugatch, 2019; Bouguen, Filmer, Macours, & Naudeau, 2018).[6]

[5] Definitions of high-quality learning environments are shaped by theories on child development as well as empirical work that has highlighted key aspects that promote young children's learning. High-quality learning environments are characterized by age-appropriate activities (for example, integrating play and learning in early childhood); opportunities for rich dialogue between teachers and children; and emotionally supportive interactions (Burchinal, 2018).

[6] In Cambodia, there were negative effects of pre-primary expansion due to substitution away from primary school into pre-primary that was less effective in promoting ECD (Bouguen, Filmer, Macours, & Naudeau, 2018). In The Gambia, new pre-primary centers were introduced to villages without such services, but had relatively low quality compared to home environments and led to worse ECD outcomes (Blimpo, Carneiro, Jervis, & Pugatch, 2019).

Overall, evidence from HICs demonstrates that attending pre-primary education, especially high-quality early childhood care and education, both improves school readiness and particularly benefits disadvantaged groups (Heckman, 2006; Magnuson, Meyers, Ruhm, & Waldfogel, 2004; Temple & Reynolds, 2007). However, effect sizes linking quality environments with child development are small (e.g., Brunsek et al., 2017; Perlman et al., 2016), highlighting both measurement challenges in capturing the complexity of learning environments (Burchinal, 2018) and multiple influences on children's development. Existing work in many LMICs demonstrates associations between aspects of quality in pre-primary settings and ECD (Aboud, Hossain, & O'Gara, 2008; Andrew et al., 2022; Brinkman et al., 2017; McCoy & Wolf, 2018; Mwaura, Sylva, & Malmberg, 2008; Raikes, Koziol, Davis, & Burton, 2020; Rao, 2010; Rao, Richards, Sun, Weber, & Sincovich, 2019). But similar to HICs, research in LMICs has demonstrated small but significant associations between pre-primary quality and ECD, albeit with many of the same challenges noted in research on HICs (Chen & Wolf, 2021). Given the stronger link between home environments and ECD than pre-primary quality and ECD in the literature, the quality and inequality of these inputs may have differential effects on developmental trajectories.

2.4 Pre-primary and kindergartens in Egypt

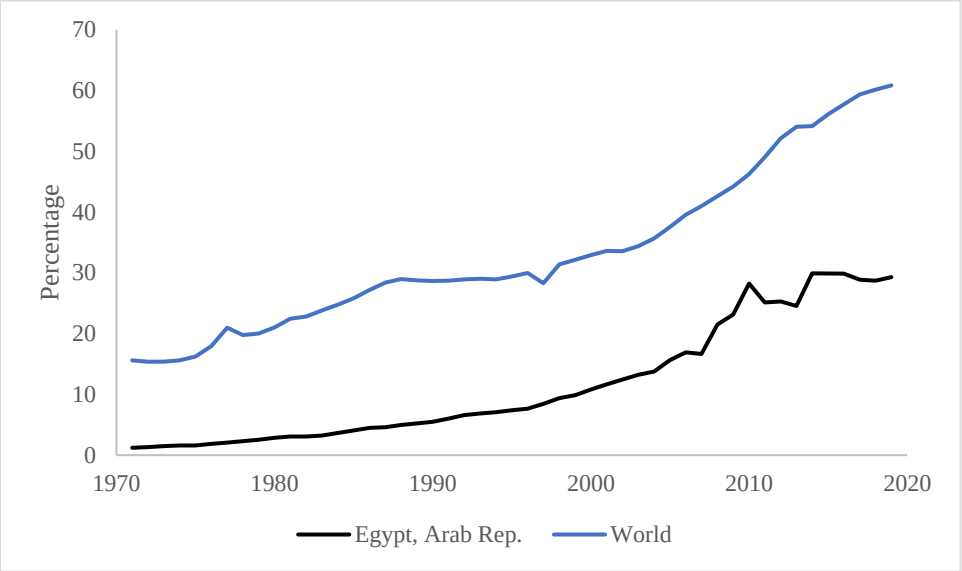
2.4.1 Egypt's pre-primary system

At age four in Egypt, children are eligible for KG, which serves children aged 4-6. KG is not compulsory, and children can enter at either KG 1 or KG 2. The KG school-day averages five hours.[7] The Ministry of Education and Technical Education (MoETE) oversees KGs and provides public KG classes in public primary schools. The majority of KG enrollment is in the public sector, with private provision at 26%.[8] Private KGs are primarily attended by children from wealthy households (El-Kogali & Krafft, 2015). There is substantial inequality in pre-primary enrollment in Egypt in general, with children from wealthier, more educated households more likely to attend pre-primary (El-Kogali & Krafft, 2015; Krafft, 2015; Krafft & El-Kogali, 2021). For instance, only 16% of children from the poorest quintile of households attended pre-primary, compared to 65% of children from the richest quintile of households. Likewise, only 20% of children with mothers who had no education attended pre-primary compared to 65% of children with mothers with higher education (El-Kogali & Krafft, 2015).

Pre-primary enrollment in Egypt has historically been substantially below the world average but has recently been rising (Figure 1). Around 2000, the pre-primary gross enrollment rate hit 10%, and reached 28% as of 2010 but then plateaued.[9] The "echo" of the youth bulge, the result of the youth bulge entering childbearing age compounded by a rise in fertility in the early 2010s, placed demographic pressure on Egypt's pre-primary and primary education system (Assaad, 2020; Krafft, 2020; Krafft & Assaad, 2014; Krafft, Assaad, & Keo, 2022).

[7] Authors' calculations based on KG sample data.
[8] Authors' calculations based on 2018/19 EMIS data. Excludes Azhari (religious) pre-primary.
[9] According to official reports, the pre-primary gross enrollment rate was down to 22% in the 2021-2022 school year (Ministry of Education and Technical Education, 2022), possibly due to the ongoing COVID-19 pandemic.

Figure 1. Pre-primary education gross enrollment rates (percentage)



Source: Authors' creation based on World Development Indicators (World Bank, 2022a)

2.4.2 Education challenges in Egypt

Generally, investment in early childhood development in the MENA region has been comparatively low (El-Kogali & Krafft, 2015). The region also tends to have the lowest scores in the world on international assessments during the primary and secondary grades (El-Kogali & Krafft, 2020). The catch-up between the earlier grades of primary school and later grades suggests that gaps in early learning may play an important role in learning and human capital challenges in the region (El-Kogali & Krafft, 2020).

Egypt has had substantial success expanding access to primary, secondary, and higher education, but education quality remains an issue (Elbadawy, 2015). Emphasis on rote memorization, large class sizes, and a focus on credentials over skills have been long-standing challenges in Egypt's education system (El-Kogali & Krafft, 2020; Elbadawy, 2015; Moustafa, Elghamrawy, King, & Hao, 2022; World Bank, 2008). Returns to education in MENA and Egypt are low and stagnant as a result of both education and labor market challenges (Krafft, Branson, & Flak, 2019; Said, Galal, & Sami, 2022; Salehi-Isfahani, Tunali, & Assaad, 2009).

2.4.3 Education 2.0 reforms

Starting in 2018, MoETE began a series of system-wide educational reforms, referred to as education 2.0 (Moustafa, Elghamrawy, King, & Hao, 2022). The new education 2.0 system was competency-based, multi-disciplinary, and aimed to foster a variety of 21st century skills. The new system also included a new approach to assessment and examination. Goals of the reform included expanding access to pre-primary education and improving the quality of education. Reforms were implemented grade by grade, starting with the pre-primary level (Moustafa, Elghamrawy, King,

& Hao, 2022).[10] The project was supported in part by a World Bank loan, including $80 million focused on pre-primary quality (World Bank, 2022b).

A new curriculum, textbooks, and teacher guides were developed, along with complementary online content (Moustafa, Elghamrawy, King, & Hao, 2022). The new materials for KGs were quite detailed, laying out a daily schedule,[11] providing teaching strategies, and detailed, scripted instructions in the teacher's guide (Ministry of Education and Technical Education, 2019).[12] Children had corresponding workbooks. Activities often required corresponding materials, e.g. manipulatives for counting. Continuous professional development was planned, with initial training on the new education system and materials offered and ongoing training planned. Training was primarily offered in a cascade model (Moustafa, Elghamrawy, King, & Hao, 2022). The standard amount of professional training was three days per term.

3 Hypotheses, data, and methods

3.1 *Hypotheses*

We hypothesize that there are disparities in children's access to quality environments (in-home and out-of-home) as well as in child development. We have three specific hypotheses:

1) Egyptian pre-primary students have unequal ECD that depends on their SES, with higher SES children demonstrating more developed skills and competencies.

2) Egyptian pre-primary students have experienced unequal home environments that depend on their SES, with higher SES children experiencing more stimulating and supportive home learning environments.

3) Egyptian pre-primary students have unequal pre-primary environments that depend on their SES, with higher SES children experiencing higher quality pre-primary learning environments.

We test these hypotheses for outcomes based on factor analyses for ECD, pre-primary quality and its dimensions, and home stimulation. We use data from a sample of KGs designed to be nationally representative and assess the magnitude and statistical significance of relationships between outcomes and SES using descriptive approaches and regression models, as detailed below.

3.2 Data collection tools, training, and fieldwork

[10] There were four learning dimensions (learning, employability, personal empowerment, and active citizenship) which encompassed 14 life skills (creativity, critical thinking, problem-solving, cooperation, productivity, negotiation, decision-making, self-management, resilience, accountability, communication, respect for diversity, empathy, and participation) (Ministry of Education and Technical Education, 2019).

[11] The schedule for KG, provided in correspondence with MoETE, had three primary windows (sessions, multiple per day): Arabic, multi-disciplinary and math (multiple windows per week). Physical education, religion, and English language had one or two windows per week.

[12] Take-up of the new curriculum was high in our sample; 84% of classes were using the new curriculum and 80% of teachers were following the corresponding teacher's guide.

The Measuring Early Learning Quality Outcomes (MELQO) tools (UNESCO, 2017) were the foundation of data collection, locally adapted to the Egyptian context. The MELQO tools have two main components, the Measure of Early Development and Learning (MODEL) for measuring the development of children aged 3-6, and the Measure of Early Learning Environments (MELE). The MODEL collects data through a child direct assessment, parent report of child development (including home and family background), and teacher report of child development. The MELE collects data via classroom observation, a teacher interview, parent interview, and school director interview. The tools were designed specifically to measure child development and quality of early childhood education in low- and middle-income countries (Raikes et al., 2019).

The MELQO tools were developed initially and piloted in 2015 in non-representative samples, and then the pilot-tested tools were used in national studies starting in 2016. The tools were finalized and publicized in 2017 (Raikes et al., 2019). The tools were selected for a nationally representative study of kindergarten teaching and learning in Egypt. The primary goal of the Egyptian data collection was to identify quality issues and inform subsequent teacher training efforts for Education 2.0, as well as to validate a new quality assurance system.

The MELQO tools were translated into Arabic and adapted to the Egyptian context and curriculum in collaboration with the MOETE, kindergarten teachers, and kindergarten supervisors. An adaptation workshop occurred in May 2019 that included a careful review of items by a group of stakeholders along with addition or modification of items to align with national standards and cultural priorities (for example, items specifically focused on the implementation of Egypt's new standards for pre-primary classrooms). The tools were programmed into Android tablets using ODK-X software (Brunette et al., 2017). Pre-piloting of the instruments subsequently took place in Egypt in two governorates, ten schools, ten classrooms, with ten teachers and 30 children. Training of the master trainers, a mix of MOETE officials, supervisors, and Egyptian academic experts, by the international experts took place in January 2020. Training of enumerators took place over 10 days starting in late February 2020, including piloting in schools. Enumerators were required to reach scores of at least 80% on activities and quizzes during training, to ensure adequate inter-rater reliability. Enumerators were graduates of faculties of kindergarten education or child psychology, or kindergarten teachers or supervisors. Data collection was initially scheduled to take place in mid-March 2020. On the date data collection was supposed to begin, schools were closed due to COVID-19.

In Fall 2021, public schools reopened on October 9. After schools opened, a repeat of training was held for enumerators. Data collection in schools took place from November 6, 2021, to December 8, 2021. Parents were interviewed over the phone through December 15, 2021.

3.3 Sample

The study sample was designed to be nationally representative of Egyptian KGs and their students. Egypt's Education Management Information System (EMIS) database from 2018-19 was the sample frame. The sample was stratified by type (public versus private), region,[13] and community

[13] Regions were divided into: Urban Governorates, Lower Egypt, and Upper Egypt. Frontier Governorates will not be included.

poverty status.[14] Within each public/private, region, and poverty status strata, a random sample totaling 46 districts was drawn.[15] Five schools were randomly selected within each district.[16] A total of 214 schools were sampled.[17] Data from 213 schools are included in this study.[18]

Data were collected for up to three KG1 and three KG2 classes per school (randomly selected if more than three). There were 638 classrooms with child and teacher data completed. A random sample of four children per classroom was selected. The sample of children whose data were successfully collected was 2,455 observations.[19] The data collection firm tried up to three times to reach parents, based on phone numbers provided by the school. For the parent data, there was substantial non-response (primarily that parents did not pick up, but some refusal when reached) such that only 1,437 parents were reached and consented.[20] We focus on the sub-sample with parental data in order to be able to investigate home environments and inequality.

3.4 Outcomes

We examine three main categories of outcomes: early childhood development (collected through direct assessments and teacher reports), pre-primary quality (collected through observations), and stimulation at home (collected through parent reports). We summarize a large number of variables (as detailed in the appendix) into factors using confirmatory factor analysis.[21] The only selection criteria was that the first factor has an eigenvalue of at least one. We kept even items with low loadings in making the index, but since the loadings were small, they have a small role in determining the value of the factor.

For ECD, we examine:

- Literacy skills
    - From the direct assessment: literacy interest; expressive language; expressive vocabulary; letter identification; letter sound identification, initial sound discrimination; listening comprehension; name writing; shape copying; receptive spatial vocabulary
    - From the teacher report: letter, name and word writing, text directionality, letter names, and picture drawing
- Math skills

[14] Poverty rates distinguish between poor, high-poverty communities (50% poverty rate or above) and non-poor, lower poverty communities (below 50% poverty rate).
[15] Districts were randomly selected probability proportional to size (based on the number of schools), with replacement. Districts were drawn from within regions and based on the poverty status within a region (33% poor schools as cutoff).
[16] If there are fewer than five schools within a district and strata, all schools were used (one to four).
[17] Seven of the originally selected schools were unavailable (closed, in renovations, etc.) and random replacement schools, as much as possible from the same strata, were used.
[18] Weather precluded completing one school.
[19] Only one child did not consent; 97 child observations were not completed by enumerators, for an overall response rate of 96%.
[20] Relative to the planned 2,552 child observations, this is a response rate of 56%. Only 10 parents, when reached, did not consent.
[21] The appendix details the factor analysis; for full questions and responses see questionnaires, available at https://carolinekrafft.com/wp-content/uploads/2022/10/Diagnostic-KG-Instruments-ENGLISH-upload-2022.10.14-CGK.pdf.

    - From the direct assessment: verbal counting; producing a set; number identification; number comparison; simple addition
    - From the teacher report: shape identification; color identification; counting; size comparison; time comparison; number comparison
- Executive function
    - From the direct assessment: head, toes, knees and shoulders tasks; forward digit span; pencil tap
- Socio-emotional skills
    - From the direct assessment: perspective taking; understanding feelings
    - From the teacher report: on task; instructions; planning; stopping; interrupting; hardworking; curiosity; responsibility; consideration; collaboration; helping others; taking turns; sharing; adjusting to transitions; settling; self-control; kicking/pushing/poking; upset when left; sadness; describing feelings; play pretend
- An overall "school readiness" factor including all these items

For pre-primary quality, we examine:

- Teaching practices
    - From the classroom observation: math; reading and writing; expressive language; books or stories; tell stories; fine motor skills; singing/music; major motor skills; modifying bad behavior; oral praise; participation; wait time; supervised; individualized; track children's development
- Environment
    - From the classroom observation: space inside the class; seats/writing surface; yard space; games/equipment for major motor activities; soap/water; handwashing; clean/appropriate toilets; safety hazards
- Materials
    - From the classroom observation: portfolios; textbooks; writing utensils; art; fantasy play; blocks; education toys or math materials; storybooks; activities hall essentials; number of storybooks
- Adherence to the curriculum
    - From the classroom observation: education 2.0 curriculum used; preparation record matches lesson; schedule followed
- Teacher attitudes:
    - From the teacher interview: job satisfaction; feels valued; job importance; professional support; training; understands education 2.0; overwhelmed

For stimulation at home, we examine, based on the parent reports, children's books at home, and in the past 7 days engaging in the following activities: reading at home, singing songs, playing, telling stories.

3.5 Covariates

We control for child sex and the child's age in months in our models. In terms of family background, we include a number of items we refer to in brief as socio-economic status (SES). An asset index based on a factor analysis of owning various durable goods and housing conditions is included in the SES domain. Data on mother (or female caregiver) and father (or male caregiver)

education level, along with corresponding parental occupation was also included in the domain of SES. We describe the characteristics of our sample in terms of mother and father characteristics in the appendix.

3.6 Methods

We undertake confirmatory factor analysis to generate our key outcomes. We provide details on the factor analyses in the appendix, and illustrative examples in the body of the paper.

We present descriptive statistics on inequality in KG students' development, pre-primary quality, and home stimulation by SES. We use visualizations of mean outcomes by mother's and father's characteristics and local polynomials (using a triangle kernel) of outcomes relative to the continuous asset index. In additional descriptives we show how stimulation at home and different aspects of pre-primary quality are related (also using local polynomials), highlighting how the different inputs to ECD can potentially offset or compound inequality in ECD.

We estimate a series of ordinary least squares (OLS) models for these different outcomes including SES. Denote the outcome for child i as Y_i. Denote the covariates as $ME_{i,j}$ for mother's education, $FE_{i,j}$ for father's education, $MO_{i,j}$ for mother's occupation, $FO_{i,j}$ for father's occupation, A_i for the asset index, S_i for child sex, and C_i for child's age in months. We thus estimate:

$$Y_i = \alpha + \beta_j ME_{i,j} + \delta_j FE_{i,j} + \gamma_j MO_{i,j} + \eta_j FO_{i,j} + \kappa A_i + \lambda S_i + \theta C_i + \varepsilon_i$$

We cluster standard errors on the school level. Since different aspects of SES are likely to be multicollinear, and since we are testing a number of individual covariates, we also undertake tests for the joint significance of the categorial SES variables (mother's education; father's education; mother's occupation; father's occupation).

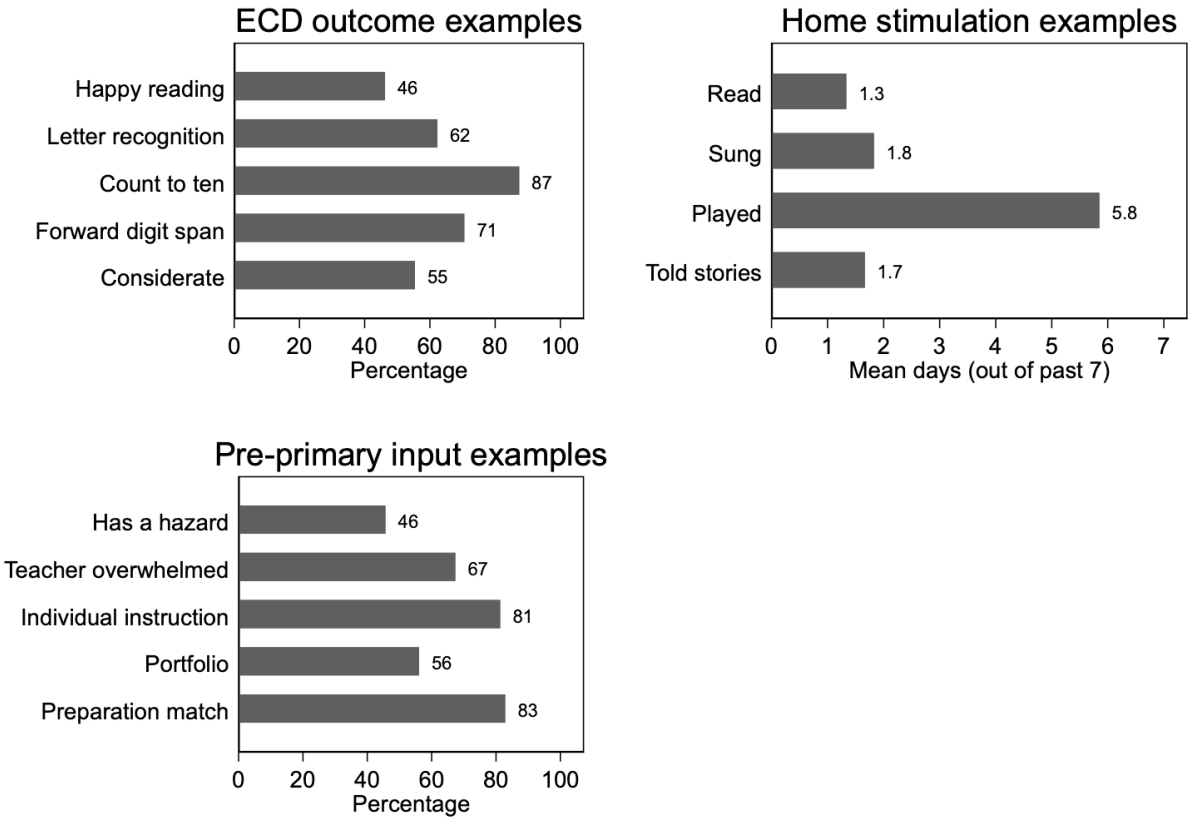
Weights are used in all our analyses. The weights incorporate the original sampling design, including on the school level, random sampling of classes, and random sampling of students. Weights also account for non-response. Non-response accounts for the number of observations that should have been included (for example, the number of children or parents per class or per school).

4 Results

4.1 Examples of outcomes and inputs

In Figure 2 we provide examples of ECD outcomes, home stimulation, and pre-primary inputs, in order to provide some sense of the ECD, home, and pre-primary context in Egypt. While only 46% of children reported being happy while reading in the direct assessment, 55% are always or often considerate per the teacher report, 62% of the time children correctly recognize letters in the direct assessment, 71% of the time they had accurate forward digit span (direct assessment), and 87% of the time they could count to ten (direct assessment).

Figure 2. Examples of early childhood development (ECD) outcomes and home and pre-primary inputs



Source: Authors' calculations

In terms of home stimulation, parents were asked how many days in the last 7 (from 0-7) someone in the household engaged in various activities with the child. Reading was rarest (1.3 days on average), followed by telling stories (1.7 days), singing (1.8 days) and then most frequently playing (5.8 days). Data from pre-primary observations revealed that 46% of children attended a pre-primary with at least one physical hazard and 67% attended a pre-primary where the teacher agreed or strongly agreed they were overwhelmed by their work. Although only 56% had a portfolio to track their development, 81% of children were in classes where children received individual instruction during the observation, and in 83% of cases the preparation record matched the schedule in the teacher's guide. The results exhibit meaningful variation; while some children are achieving key ECD benchmarks and experiencing high-quality inputs, others are not.

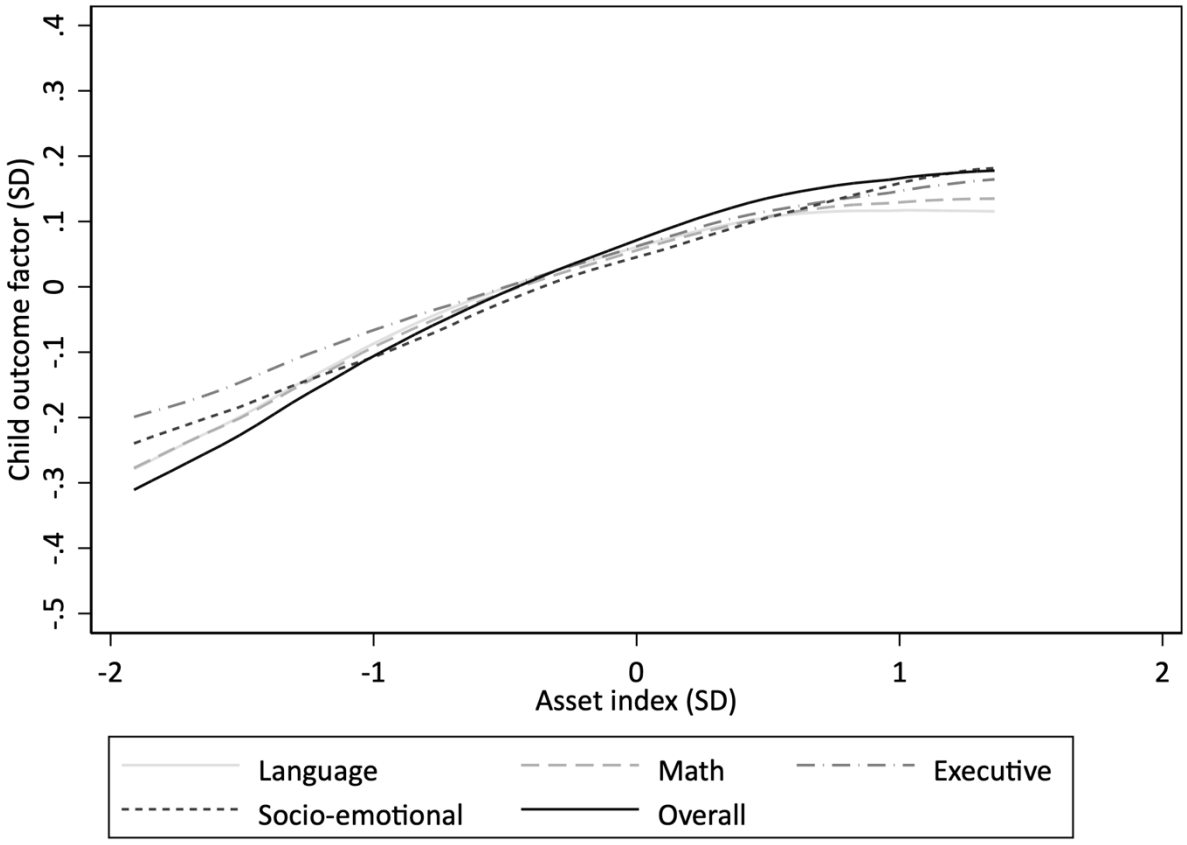
4.2 Inequality in early childhood development outcomes

In this section, we substantiate inequality in ECD by SES (testing H1). We examine the language, math, executive function, socio-emotional, and overall school readiness ECD outcomes and how they vary by SES. Figure 3 presents the patterns of the various ECD development outcomes by the asset index, based on a local polynomial (triangle kernel). Figure 4 shows ECD outcomes by

mother's and father's education and father's occupation (few mothers work). Table 1 shows multivariate models of how ECD outcomes depend on SES, controlling for child sex and age.

Within specific domains of child development and across all domains there is a clear socio-economic gradient in ECD (consistent with H1). Descriptively, there is a very similar pattern for all outcomes. In the multivariate models, the magnitude of the relationship is relatively similar; a one SD increase in the asset index predicts between a 0.111 and 0.171 SD increase in the ECD outcome, depending on the outcome (consistent with H1). All are statistically significant at the 5% level except for executive functioning (0.111).

Figure 3. Child outcome factors (in standard deviations [SD]) by asset index (in SD)

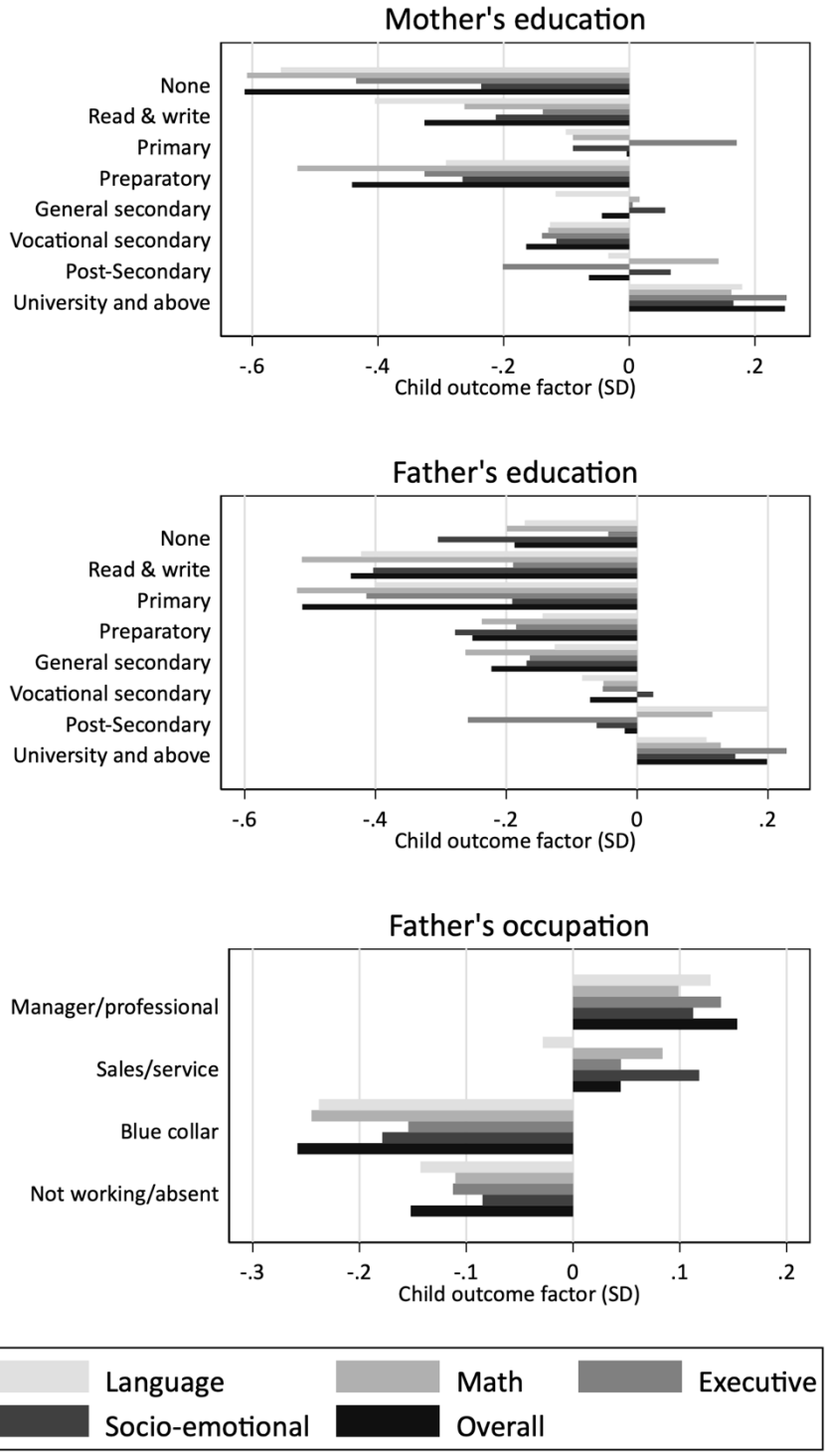


Source: Authors' calculations
Notes: Local polynomial with triangle kernel, bandwidth two. Visualizing from 1st-99th percentile.

There are particularly large differences in child outcomes by mother's education (consistent with H1). Descriptively (Figure 4), children of mothers reporting no formal education have scores on the school readiness factor of -0.61 (factors are normalized, so factors are measured in standard deviations), compared to -0.16 for mothers with vocational secondary (the most common degree in Egypt (Krafft, Assaad, & Keo, 2022), although university is the most common in the sample, since enrollment in pre-primary is itself unequal). Only at the university level is readiness above average (0.25).

In the multivariate models, mother's education is jointly significant in predicting math, executive functioning, and overall school readiness skills (consistent with H1). Compared to a mother with no education, a mother with university education predicts an 0.555 SD higher overall readiness factor. There are similar but somewhat smaller descriptive disparities by fathers' education, father's occupation, and mother's occupation (which are all highly correlated with mother's education and other aspects of SES). None of the categories is jointly significant in any of the models. Overall, there are clear socio-economic disparities (consistent with H1), most closely related to mother's education, but also tied to household wealth and income (proxied by the asset index).

Figure 4. Mean child outcome factors (in standard deviations [SD]) by parental education, father's occupation



Source: Authors' calculations

Table 1. OLS models of socio-economic inequality in early childhood development outcomes

	Language	Math	Exec. function	Socio-emo.	Overall readiness
Asset factor	0.121*	0.113*	0.111	0.171***	0.151**
	(0.053)	(0.052)	(0.057)	(0.048)	(0.052)
Mother's ed. (none omit.)					
Read & write	0.379	0.545	0.411	0.088	0.490
	(0.255)	(0.291)	(0.251)	(0.328)	(0.254)
Primary	0.462*	0.555*	0.636**	0.149	0.635**
	(0.225)	(0.242)	(0.218)	(0.170)	(0.224)
Preparatory	0.304	0.073	0.118	-0.137	0.179
	(0.169)	(0.209)	(0.153)	(0.153)	(0.163)
General secondary	0.305	0.451*	0.297	0.143	0.382
	(0.214)	(0.211)	(0.215)	(0.210)	(0.194)
Vocational secondary	0.308	0.321	0.178	-0.085	0.277
	(0.166)	(0.178)	(0.141)	(0.137)	(0.152)
Post-Secondary	0.303	0.508**	0.083	0.083	0.296
	(0.194)	(0.177)	(0.183)	(0.175)	(0.170)
University and above	0.548**	0.540**	0.427*	0.028	0.555**
	(0.184)	(0.188)	(0.179)	(0.158)	(0.177)
Father's ed. (none omit.)					
Read & write	-0.617**	-0.657*	-0.438	-0.356	-0.655**
	(0.235)	(0.257)	(0.259)	(0.205)	(0.247)
Primary	-0.446	-0.541	-0.542*	-0.012	-0.566*
	(0.238)	(0.277)	(0.233)	(0.206)	(0.258)
Preparatory	-0.027	-0.090	-0.231	-0.071	-0.151
	(0.165)	(0.191)	(0.202)	(0.186)	(0.172)
General secondary	-0.156	-0.353	-0.262	-0.101	-0.284
	(0.211)	(0.279)	(0.215)	(0.294)	(0.211)
Vocational secondary	-0.246	-0.186	-0.210	0.138	-0.223
	(0.172)	(0.187)	(0.153)	(0.152)	(0.161)
Post-Secondary	-0.127	-0.193	-0.496*	-0.087	-0.336
	(0.201)	(0.223)	(0.216)	(0.233)	(0.184)
University and above	-0.371	-0.250	-0.185	0.018	-0.289
	(0.201)	(0.203)	(0.183)	(0.169)	(0.188)
Mother's occupation (manager/prof. omit.)					
Sales/service	-0.137	-0.015	-0.231	-0.103	-0.167
	(0.198)	(0.261)	(0.216)	(0.147)	(0.192)
Blue collar	-0.410	-0.393	-0.201	-0.482	-0.429
	(0.270)	(0.370)	(0.266)	(0.375)	(0.306)
Not working/absent	-0.049	-0.005	-0.095	-0.033	-0.065
	(0.107)	(0.074)	(0.100)	(0.092)	(0.071)
Father's occupation (manager/prof. omit.)					
Sales/service	-0.022	0.140	0.098	0.087	0.086
	(0.128)	(0.085)	(0.119)	(0.133)	(0.109)
Blue collar	-0.102	-0.047	0.018	-0.112	-0.059
	(0.105)	(0.095)	(0.107)	(0.121)	(0.104)
Not working/absent	-0.086	0.006	-0.046	-0.101	-0.068
	(0.110)	(0.113)	(0.118)	(0.122)	(0.108)
Child sex (female omit.)					
Male	-0.103	-0.072	-0.072	-0.306***	-0.125*

	Language	Math	Exec. function	Socio-emo.	Overall readiness
	(0.054)	(0.059)	(0.071)	(0.054)	(0.057)
Child age (in months)	0.058***	0.056***	0.040***	0.017**	0.059***
	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)
Constant	-3.847***	-3.833***	-2.553***	-0.915*	-3.898***
	(0.352)	(0.394)	(0.384)	(0.390)	(0.361)
N (obs.)	1308	1308	1308	1308	1308
R-sq.	0.327	0.318	0.194	0.127	0.359
P-val. model	0.000	0.000	0.000	0.000	0.000
P-val. Moth. ed.	0.153	0.016	0.030	0.597	0.023
P-val. Fath. ed	0.118	0.160	0.210	0.087	0.296
P-val. Moth. oc.	0.442	0.757	0.611	0.569	0.418
P-val. Fath. oc.	0.781	0.347	0.769	0.448	0.670

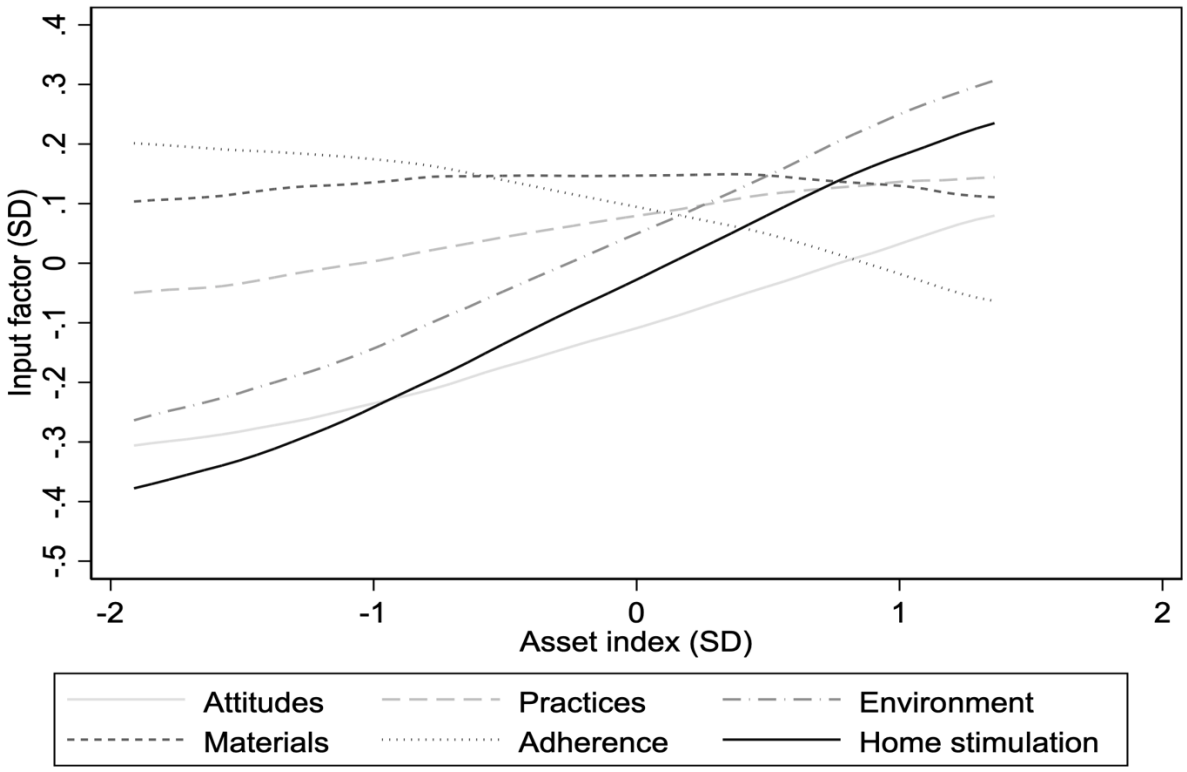
Source: Authors' calculations

Notes: *p<0.05; **p<0.01; ***p<0.001. Standard errors clustered on the school level.

4.3 Inequality in inputs

We now turn to examining inequality in home and pre-primary inputs by SES. In Figure 5, we explore the patterns of pre-primary quality and home inputs by the families' asset index, based on a local polynomial (triangle kernel). Figure 6 shows the variation in stimulation by mother's and father's education and father's occupation. Table 2 shows OLS models for SES and the various home and pre-primary inputs (testing H2 and H3). There is substantial variation in the relationship between inputs and assets. Strong relationships were observed between home stimulation and pre-primary environments, and the family asset index. A one SD increase in the asset index predicts a statistically significant 0.197 SD increase in home stimulation (consistent with H2). There are similar (and likewise significant) relationships of around 0.19 SD increases in the pre-primary environment or teacher attitudes for each SD increase in assets (consistent with H3). Other results for teaching practices (coefficient of 0.117), materials (-0.006) and adherence to the curriculum (-0.069) were not significantly associated with family assets.

Figure 5. Input factors (in standard deviations [SD]) by asset index (in SD)

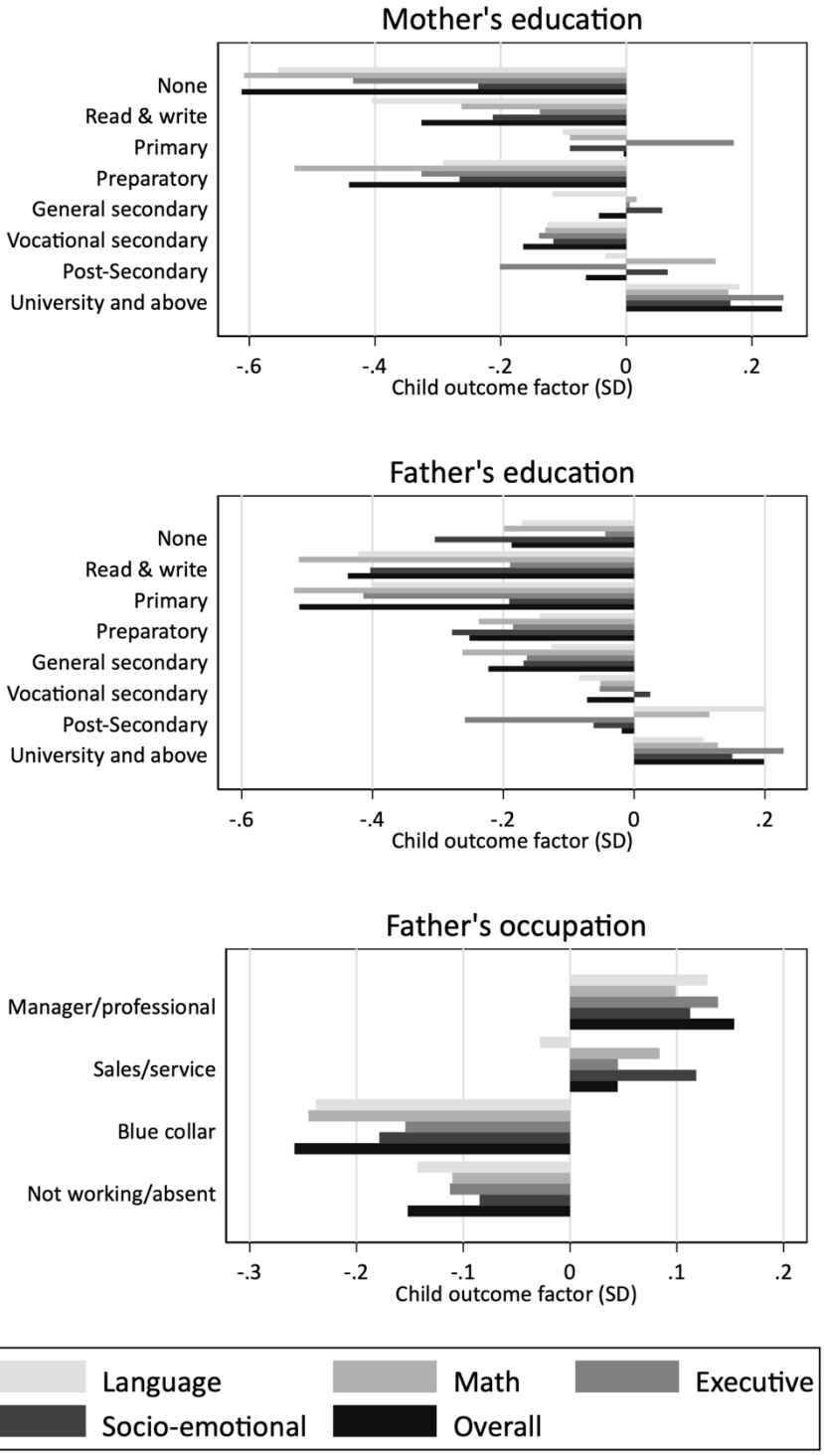


Source: Authors' calculations
Notes: Local polynomial with triangle kernel, bandwidth two. Visualizing from 1st-99th percentile.

Although there are descriptive differences in a number of inputs by parent's characteristics (Figure 6), only a few are statistically significant. For instance, children of mothers with no education experience an average of a -0.57 stimulation factor, compared to 0.27 for those with university-educated mothers. Mother's education is jointly significant for home stimulation (consistent with H2) and teaching practices (consistent with H3, but only for this outcome) (Table 2). There are not significant differences for any of the inputs by father's education, using the joint tests. Mother's occupation is significant for teaching practices and curriculum adherence, but with children of mothers engaged in sales and service jobs having better outcomes than children whose mothers are in managerial/professional jobs. However, few mothers work at all. Father's occupation is only statistically significant for home stimulation, with all other statuses having significantly lower home stimulation (by -0.185 to -0.322 SDs) compared to managerial/professional fathers.

Although we have only one measure of home environment quality (stimulation at home), it is notable that we see stronger inequities in home environments than in pre-primary environments. While different types of pre-primary inputs vary substantially in terms of their inequality, they are less unequal than home stimulation, particularly for materials and adherence to the curriculum, and to some extent teaching practices.

Figure 6. Mean input factors (means, in standard deviations [SD]) by parental education and father's occupation



Source: Authors' calculations

Table 2. OLS models of socio-economic inequality in home and pre-primary inputs

	Home stimulation	Environment	Attitudes	Teaching practices	Materials	Adherence
Asset factor	0.197***	0.188**	0.189***	0.117	-0.006	-0.069
	(0.034)	(0.065)	(0.051)	(0.075)	(0.072)	(0.058)
Mother's ed. (none omit.)						
Read & write	-0.082	0.385	0.083	-0.179	0.230	-0.048
	(0.156)	(0.329)	(0.237)	(0.266)	(0.238)	(0.183)
Primary	0.308	0.613	-0.192	0.224	0.550*	0.030
	(0.232)	(0.313)	(0.256)	(0.202)	(0.219)	(0.106)
Preparatory	0.136	0.268	0.016	0.082	0.123	-0.020
	(0.176)	(0.227)	(0.218)	(0.213)	(0.174)	(0.149)
General secondary	0.198	0.498	-0.044	-0.219	-0.172	0.096
	(0.178)	(0.350)	(0.207)	(0.242)	(0.246)	(0.154)
Vocational secondary	0.098	0.432	-0.031	0.111	0.221	0.141
	(0.134)	(0.275)	(0.206)	(0.195)	(0.179)	(0.100)
Post-Secondary	0.184	0.709*	-0.097	0.354	0.261	0.011
	(0.164)	(0.284)	(0.232)	(0.218)	(0.209)	(0.167)
University and above	0.278	0.596*	0.047	0.056	0.211	-0.064
	(0.145)	(0.289)	(0.224)	(0.228)	(0.226)	(0.153)
Father's ed. (none omit.)						
Read & write	0.071	0.378	0.020	-0.013	0.223	0.223
	(0.175)	(0.299)	(0.289)	(0.203)	(0.185)	(0.122)
Primary	0.043	0.337	0.031	0.316	0.336	0.263*
	(0.190)	(0.273)	(0.207)	(0.182)	(0.171)	(0.129)
Preparatory	0.012	-0.043	-0.113	0.124	0.164	0.114
	(0.146)	(0.225)	(0.164)	(0.220)	(0.213)	(0.129)
General secondary	-0.019	0.317	-0.080	0.606*	0.020	0.073
	(0.155)	(0.325)	(0.247)	(0.292)	(0.261)	(0.268)
Vocational secondary	0.045	0.263	-0.051	0.238	0.187	0.130
	(0.105)	(0.217)	(0.132)	(0.159)	(0.137)	(0.114)
Post-Secondary	-0.099	0.287	-0.096	0.216	0.209	0.097
	(0.126)	(0.265)	(0.151)	(0.211)	(0.171)	(0.130)
University and above	0.219	0.338	0.061	0.242	-0.044	0.043
	(0.131)	(0.269)	(0.158)	(0.201)	(0.170)	(0.150)
Mother's occupation (manager/prof. omit.)						
Sales/service	0.139	0.140	0.357	0.487**	0.567*	0.479**
	(0.193)	(0.155)	(0.226)	(0.175)	(0.228)	(0.171)
Blue collar	0.035	0.493*	0.123	0.509	-0.006	0.297
	(0.121)	(0.201)	(0.374)	(0.362)	(0.213)	(0.194)
Not working/absent	0.082	0.114	0.176	0.096	0.027	0.053
	(0.068)	(0.095)	(0.108)	(0.124)	(0.131)	(0.138)
Father's occupation (manager/prof. omit.)						
Sales/service	-0.264**	-0.132	0.007	-0.108	-0.172	-0.151
	(0.098)	(0.103)	(0.110)	(0.104)	(0.112)	(0.125)
Blue collar	-0.185*	-0.246*	-0.015	-0.015	-0.184	0.021
	(0.090)	(0.110)	(0.095)	(0.087)	(0.104)	(0.072)
Not working/absent	-0.322**	0.011	0.014	0.209*	-0.077	-0.199
	(0.106)	(0.121)	(0.131)	(0.101)	(0.106)	(0.137)
Child sex (female omit.)						

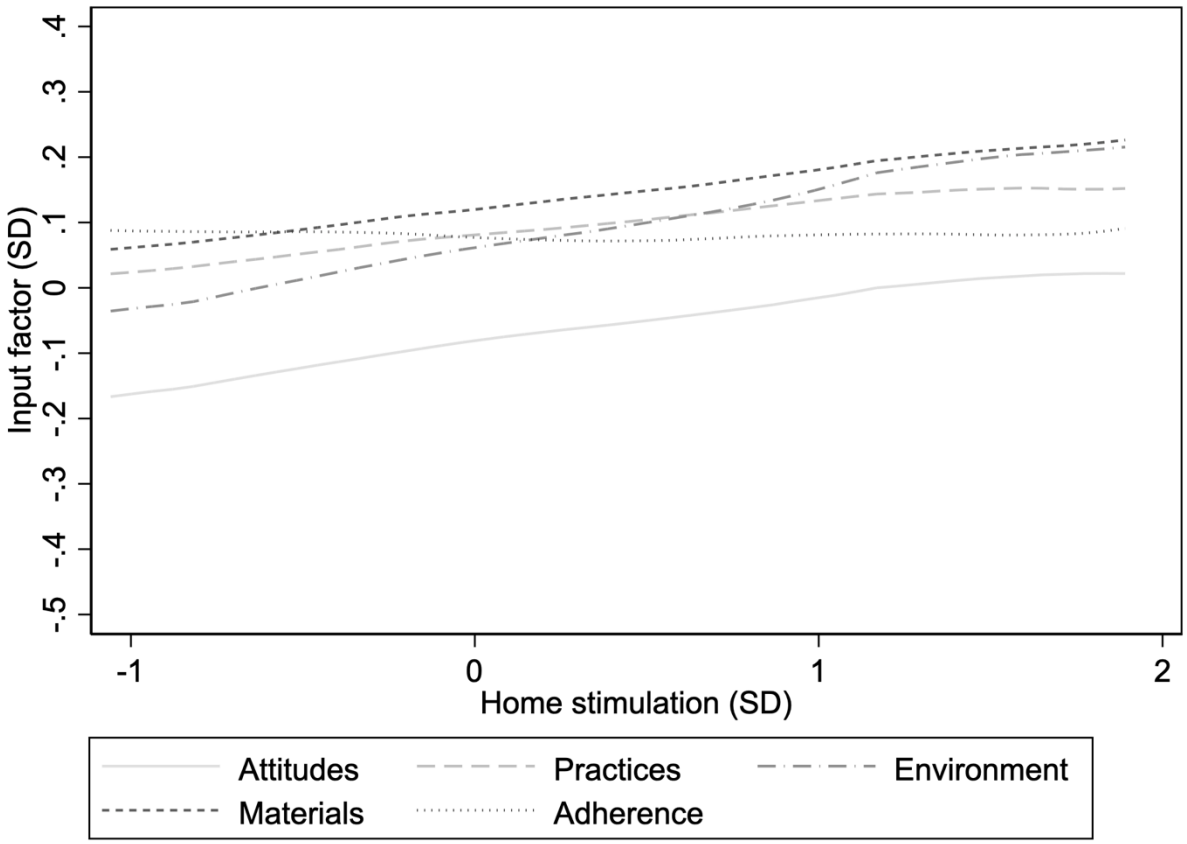
	Home stimulation	Environment	Attitudes	Teaching practices	Materials	Adherence
Male	0.035	0.020	0.030	0.033	0.047	0.012
	(0.047)	(0.056)	(0.053)	(0.058)	(0.060)	(0.061)
Child age (in months)	0.000	0.004	-0.008	0.016**	0.021***	0.013*
	(0.003)	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)
Constant	-0.310	-1.026*	0.274	-1.410*	-1.520**	-0.933
	(0.270)	(0.516)	(0.543)	(0.543)	(0.497)	(0.553)
N (obs.)	1308	1302	1308	1302	1302	1302
R-sq.	0.233	0.181	0.086	0.078	0.090	0.081
P-val. model	0.000	0.000	0.000	0.000	0.000	0.101
P-val. Moth. ed.	0.014	0.175	0.556	0.028	0.110	0.282
P-val. Fath. ed	0.064	0.785	0.633	0.272	0.407	0.417
P-val. Moth. oc.	0.617	0.108	0.328	0.018	0.072	0.003
P-val. Fath. oc.	0.005	0.085	0.996	0.085	0.291	0.359

Source: Authors' calculations

Notes: *p<0.05; **p<0.01; ***p<0.001. Standard errors clustered on the school level.

In Figure 7 we specifically explore the relationship between home inputs (home stimulation) and pre-primary inputs, based on a local polynomial (triangle kernel). The correlations between home stimulation and pre-primary inputs are modest, with home stimulation not strongly correlated with quality of pre-primary environments. The strongest correlation (0.17) is with the environment, followed by teacher attitudes (0.13), materials (0.10) and teaching practices (0.08). Adherence to the curriculum is not correlated with stimulation at home (-0.02). Generally, students with more stimulating home environments are experiencing slightly higher quality pre-primary inputs.

Figure 7. Pre-primary input factors (in standard deviations [SD]) by home stimulation factor (in SD)



Source: Authors' calculations
Notes: Local polynomial with triangle kernel, bandwidth two. Visualizing from 1st-99th percentile.

5 Discussion and conclusions

5.1 Summary

Using a representative sample, this study provides documentation of early disparities in children's learning outcomes and the quality of home and pre-primary learning environments. Our analyses demonstrate that early disparities documented in many countries are also evident in Egypt. We document disparities in children's learning outcomes in pre-primary. There are differences in children's language, math, executive function, socio-emotional, and overall school readiness outcomes by SES, particularly mother's education (consistent with H1). The role of mother's education may reflect substantial gender inequality in care work in Egypt (Economic Research Forum & UN Women, 2020; El-Feki, Heilman, & Barker, 2017), as mothers are typically the primary caregivers for children with much less direct involvement from fathers.

We also observe disparities in home learning environments (consistent with H2) and in pre-primary quality (consistent with H3). There are socio-economic differences in children's home stimulation and components of their pre-primary education experience (including environment and teacher attitudes). Children who experience lower-quality home learning environments also experience lower-quality pre-primary education in some regards, but not all. Inequities are largest for structural quality (the pre-primary physical environment), whereas there is less inequity in process quality (teacher practices, children's experience of quality materials, and adherence to the curriculum).

5.2 Limitations

Our results indicate important disparities in ECD, home stimulation, and some aspects of pre-primary quality and inputs that are critical to address. However, there are a number of limitations to our results that must be kept in mind and point to important areas for future work and research. First, we were only able to estimate correlations between SES, outcomes, and inputs. The causal effects of inputs, particularly pre-primary inputs, in LMICs are under-researched and an important area for future work. Second, we were comparing one measure of home stimulation to multiple dimensions of pre-primary quality. There may be other aspects of the home environment that we were not able to observe that are more or less unequal. Measuring quality of home stimulation or pre-primary learning environments is quite challenging, as is measuring the learning and development of young children (Burchinal, 2018). Ongoing efforts to improve measurement of ECD and early environments may reveal additional variation in inequality. Additionally, we do not know if one type of input (home or pre-primary, or a particular aspect of pre-primary quality) is more important than another in determining ECD.

Our analyses are based on a sample of pre-primary students. Not all children in Egypt attend pre-primary; indeed, there is substantial socio-economic inequality in access to pre-primary (El-Kogali & Krafft, 2015). In the general population of pre-primary aged children (including those not attending pre-primary), there may be different patterns of inequality in home environments. The children not enrolled in pre-primary might particularly benefit from pre-primary or might particularly suffer from low-quality or inequitable pre-primary if they attended pre-primary; our research is not able to assess these dynamics, and they remain an important area for future research.

The sample we used from Egypt was designed to be nationally representative of pre-primary students, however, there was substantial non-response in the parental sample, which we use to measure SES. As Table 3, in the appendix, shows, there are some differences between our parental sample and a nationally representative sample of parents of KG students. The respondents in our sample were of slightly higher SES. This bias in the sample will not necessarily bias our research questions on SES unless there is a differential relationship among the respondents.

Our data collection efforts were also in late 2021, during the ongoing COVID-19 pandemic. While children were again attending pre-primary in person, the pandemic may have affected outcomes in complex ways that we are unable to unpack. These results do not necessarily generalize to other contexts, although future research should investigate the relative role of pre-primary and home environments in other LMICs.

5.3 Policy implications

Our findings point to two avenues for improving ECD and equity in ECD that can be pursued in parallel: First, investments in upgrading the pre-primary inputs that are relatively equal can help close ECD gaps for children who do attend pre-primary. For instance, since adherence to the curriculum is relatively equitable, improvements in curriculum quality may in turn lead to equitable improvements in ECD among pre-primary students. Equitable improvements will likely not, however, be sufficient to address the inequities in ECD that pre-date pre-primary and inequality in other pre-primary inputs.

Thus, second, targeted efforts should address the socio-economic inequality in both home and pre-primary environments. Efforts must target children from less advantaged socio-economic backgrounds to ensure all children have equitable home environment, pre-primary, and ultimately ECD experiences. Although structural aspects of pre-primary quality may be easier for policy makers to standardize, they were more unequal than process components such as pedagogy. Addressing these structural inequities could help pre-primary better reduce gaps in school readiness for disadvantaged children. All these inputs should only be targets of policy inasmuch as they yield improvements in ECD. Although the literature suggests pre-primary quality and particularly the home environment matter for ECD, establishing which specific inputs have the highest causal impact on ECD within the Egyptian context would be valuable for informing policy.

Given the strong self- and cross-productivity of ECD skills (Helmers & Patnam, 2011), multi-dimensional inequality is likely to compound over time. Approaches to addressing learning poverty should likely focus on compensatory models that aim to provide extremely high-quality pre-primary education to children most at risk for poor ECD (which is the opposite of what we typically see in Egypt). Redressing inequality in early learning can not only improve outcomes and close gaps for disadvantaged students, it can also benefit their peers, improving learning for all (Berlinski, Busso, & Giannola, 2022).

However, the effects of pre-primary and pre-primary quality on school readiness and potentially compensating for inequitable home environments can be complex. For instance, an experiment in Mauritius showed that high quality pre-primary benefited children with low educated fathers, but led to worse outcomes for children with poorly educated mothers (Morabito, De, & Figueroa, 2018). Efforts to improve pre-primary quality and equity must carefully assess their actual impacts to determine the mix of interventions that will be most effective in closing gaps in early learning.

An important question that our research sheds light on – but cannot fully answer – is whether pre-primary or high-quality pre-primary can close school readiness gaps for disadvantaged children. Children starting pre-primary already have unequal ECD due to unequal early home environments. If pre-primary is substantially higher quality than home environments, even if it is somewhat unequal in quality, it could still close gaps. Moreover, if pre-primary quality is similar to home environment quality on average, and less unequal (this latter condition we have confirmed in Egypt), it could also help close gaps.

While we cannot directly estimate, in our work, the impact of pre-primary and quality pre-primary on ECD or the impact of improving home environments (e.g., early stimulation interventions) in

LMICs, we can draw on the literature to assess the potential of pre-primary to close school readiness gaps. Effect sizes of pre-primary quality on learning in HICs tend to be around 0.1 if not smaller (e.g. Brunsek et al., 2017; Perlman et al., 2016). However, one recent meta-analysis found effect sizes of 0.25 on children's skills for interventions designed to improve pre-primary quality in HICs and 0.16 for pre-primary quality in LMICs (Holla, Bendini, Dinarte, & Trako, 2021). Quality improvements also had larger impacts than efforts to improve access (Holla, Bendini, Dinarte, & Trako, 2021). Interventions that improve home learning environments tend to have effect sizes in the 0.2-0.3 range if not larger (Dong, Dong, Wu, & Tang, 2020; Knauer, Ozer, Dow, & Fernald, 2019; Zuilkowski, McCoy, Jonason, & Dowd, 2019).

As a point of reference, in Egypt, having a mother with no education versus a university education was associated with a raw readiness gap of 0.86 standard deviations. Trying to close the readiness gap with targeted pre-primary quality interventions alone would require a 5.4 standard deviation increase in pre-primary quality (using an effect size of 0.16 (Holla, Bendini, Dinarte, & Trako, 2021)). Improvements via home learning environments would require 2.9-4.3 standard deviation increases in home environments. These back-of-the-envelope calculations suggest targeted efforts towards ***both*** home environment and pre-primary quality are needed to help close school readiness gaps.

5.4 Areas for future research

Our findings point to several important areas for future research and data collection to inform policy. Nationally representative data at the pre-primary stage are rare in LMICs (Raikes, Sayre, & Lima, 2021), and data are important pre-requisite to evidence-based efforts to address inequality. Longitudinal data on young children and the trajectory of their development in LMICs are also much needed to understand critical points for intervention.[22]

Further research on promoting pre-primary quality and the impact of quality interventions on ECD is needed. Most of the evidence on what works to promote teaching quality and learning in LMICs comes from the primary level. For instance, only 8% of studies on education in Africa focused on pre-primary (Evans & Mendez Acosta, 2021). Research exploiting the random assignment of kindergarten students in Ecuador demonstrated that teachers' classroom practices are associated with higher learning (Araujo, Carneiro, Cruz-Aguayo, & Schady, 2016). At the pre-primary level, play-based learning can be particularly important and effective (Attanasio et al., 2019; Wolf, Aber, Behrman, & Tsinigo, 2019). However, play-based approaches can also face backlash from parents or teachers (Wolf, Aber, Behrman, & Tsinigo, 2019).

In addition, further research with rigorous causal identification strategies is needed to assess whether, when, and how pre-primary may help close gaps in ECD, as well as which specific input improvements would be most effective for improving equity and learning. Efforts to examine the impact of quality pre-primary on child development should therefore include estimates of the quality of children's home learning environments, given the large impact of home environments on children's learning and potential role of pre-primary and pre-primary quality in closing gaps.

[22] The Young Lives study is an example of longitudinal data collection that can shed light on important aspects of ECD and interactions with early environments, although the data were not nationally representative (Young Lives, 2017).

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7 Appendix: Sample socio-economic characteristics

Table 3. Mother's and father's characteristics from KG sample and KG students in the Egypt Labor Market Panel Survey (ELMPS) 2018 sample

Data source:	KG sample	ELMPS 2018 KG students
Mother's highest level of schooling		
None	4.9	13.0
Read & write	1.8	3.8
Primary	4.6	4.5
Preparatory	5.0	7.6
General secondary	2.5	4.6
Vocational secondary	28.5	34.0
Post-Secondary	8.0	2.7
University and above	44.8	29.9
Father's highest level of schooling		
None	4.5	8.5
Read & write	4.1	6.7
Primary	3.9	6.4
Preparatory	4.2	2.8
General secondary	1.6	1.2
Vocational secondary	31.6	38.2
Post-Secondary	7.7	4.0
University and above	42.6	32.3
Father occupation		
Manager/professional	52.5	24.4
Sales/service	11.0	23.7
Blue collar	27.8	37.6
Not working/absent	8.7	14.3
Total	100.0	100.0
N (Observations)	1346	665

Source: Authors' calculations based on KG sample and Egypt Labor Market Panel Survey 2018

8 Appendix: Factor analyses

Table 4. Language factor analysis

	Scoring coefficient	Loading	Uniqueness
Feel: picture book	0.008	0.177	0.969
Feel: Being read to	0.013	0.193	0.963
Feel: Learning to read	0.011	0.204	0.958
Feel: Learning letters	0.012	0.188	0.965
Feel: Writing	0.012	0.163	0.973
Iteration of letter recognition	0.033	0.645	0.584
Iteration of letter recognition	0.048	0.757	0.428
Iteration of letter recognition	0.066	0.792	0.372
Iteration of letter recognition	0.079	0.834	0.304
Iteration of letter recognition	0.044	0.750	0.437
Iteration of letter recognition	0.060	0.800	0.360
Iteration of letter recognition	0.058	0.798	0.362
Iteration of letter recognition	0.066	0.801	0.359
Iteration of letter recognition	0.033	0.494	0.756
Iteration of letter recognition	0.037	0.557	0.689
Iteration of letter recognition	0.048	0.758	0.426
Iteration of letter recognition	0.046	0.712	0.493
Iteration of letter recognition	0.034	0.634	0.597
Iteration of letter recognition	0.055	0.778	0.395
Iteration of letter recognition	0.060	0.797	0.364
Iteration of letter recognition	0.028	0.619	0.617
Iteration of letter sound	0.043	0.651	0.576
Iteration of letter sound	0.049	0.685	0.531
Iteration of letter sound	0.055	0.677	0.541
Iteration of letter sound	0.054	0.696	0.515
Iteration of letter sound	0.042	0.641	0.589
Iteration of phoneme	0.013	0.252	0.936
Iteration of phoneme	0.018	0.412	0.830
Iteration of phoneme	0.006	0.113	0.987
Iteration of reading comprehension	0.012	0.216	0.953
Iteration of reading comprehension	0.017	0.277	0.923
Iteration of reading comprehension	0.025	0.304	0.907
Iteration of reading comprehension	0.013	0.222	0.951
Iteration of reading comprehension	0.024	0.374	0.860
Name writing	0.033	0.599	0.641
Copying X	0.027	0.492	0.758
Copying circle	0.018	0.314	0.901
Copying triangle	0.040	0.579	0.665
Read text correct direction	0.014	0.293	0.914
Know three letters	0.017	0.255	0.935
Know 10 letters	0.029	0.483	0.767
Write three letters	0.022	0.386	0.851
Write name	0.038	0.554	0.693
Write a word	0.031	0.481	0.769
Iteration of naming body part	0.006	0.105	0.989
Iteration of naming body part	0.007	0.147	0.978

	Scoring coefficient	Loading	Uniqueness
Iteration of naming body part	0.006	0.072	0.995
Iteration of naming body part	0.007	0.131	0.983
Iteration of naming body part	0.013	0.200	0.960
Vocabulary: eat	0.012	0.209	0.956
Vocabulary: animals	0.025	0.342	0.883
Ball on box	0.015	0.261	0.932
Ball under box	0.018	0.321	0.897
Ball in front of box	0.023	0.312	0.903
Ball in box	0.019	0.312	0.902
Draw a picture	0.007	0.116	0.987
Eigenvalue	14.268		

Source: Authors' calculations

Table 5. Math factor analysis

	Scoring coefficient	Loading	Uniqueness
Counting	0.071	0.662	0.561
Three bottle caps	0.051	0.546	0.701
Six bottle caps	0.070	0.645	0.583
Number recognition: 2	0.047	0.567	0.679
Number recognition: 6	0.089	0.751	0.436
Number recognition: 7	0.088	0.757	0.427
Number recognition: 10	0.093	0.752	0.434
Number recognition: 8	0.085	0.741	0.451
Number recognition: 5	0.074	0.710	0.496
Number recognition: 1	0.074	0.681	0.536
Number recognition: 4	0.094	0.762	0.420
Number recognition: 3	0.091	0.732	0.464
Number recognition: 9	0.100	0.776	0.397
Larger 3 or 5	0.026	0.350	0.877
Larger 8 or 6	0.043	0.477	0.773
Smaller 4 or 7	0.044	0.493	0.757
Two plus one bottle caps	0.041	0.443	0.804
Three plus two bottle caps	0.057	0.544	0.704
Four plus two bottle caps	0.084	0.626	0.608
Identify three shapes	0.033	0.313	0.902
Identify three colors	0.024	0.251	0.937
Count one to 10	0.033	0.370	0.863
Relative size	0.021	0.191	0.963
Times of day	0.015	0.186	0.966
Days	0.031	0.348	0.879
Relative weight	0.024	0.170	0.971
Number comparison	0.033	0.373	0.861
Eigenvalue	8.547		

Source: Authors' calculations

Table 6. Executive function factor analysis

	Scoring coefficient	Loading	Uniqueness
Iteration of head/knees/shoulders/toes	-0.018	-0.729	0.468
Iteration of head/knees/shoulders/toes	0.043	0.790	0.376
Iteration of head/knees/shoulders/toes	0.040	0.775	0.399
Iteration of head/knees/shoulders/toes	0.046	0.786	0.383
Iteration of head/knees/shoulders/toes	0.047	0.768	0.409
Iteration of head/knees/shoulders/toes	0.058	0.789	0.378
Iteration of head/knees/shoulders/toes	0.046	0.779	0.393
Iteration of head/knees/shoulders/toes	0.052	0.785	0.384
Iteration of head/knees/shoulders/toes	0.060	0.814	0.337
Iteration of head/knees/shoulders/toes	0.066	0.823	0.322
Iteration of head/knees/shoulders/toes	0.042	0.803	0.355
Iteration of head/knees/shoulders/toes	0.070	0.830	0.311
Iteration of head/knees/shoulders/toes	0.059	0.832	0.309
Iteration of head/knees/shoulders/toes	0.053	0.823	0.322
Iteration of head/knees/shoulders/toes	0.055	0.828	0.315
Iteration of head/knees/shoulders/toes	0.033	0.775	0.400
Forward digit span (two)	0.006	0.099	0.990
Forward digit span (three)	0.008	0.211	0.955
Forward digit span (four)	0.012	0.319	0.898
Forward digit span (five)	0.010	0.283	0.920
Iteration of pencil tap	0.019	0.454	0.794
Iteration of pencil tap	0.035	0.626	0.609
Iteration of pencil tap	0.039	0.636	0.595
Iteration of pencil tap	0.035	0.611	0.627
Iteration of pencil tap	0.039	0.639	0.592
Iteration of pencil tap	0.037	0.608	0.630
Iteration of pencil tap	0.040	0.618	0.618
Iteration of pencil tap	0.034	0.573	0.672
Iteration of pencil tap	0.028	0.532	0.717
Iteration of pencil tap	0.035	0.578	0.666
Iteration of pencil tap	0.032	0.607	0.631
Iteration of pencil tap	0.039	0.606	0.633
Iteration of pencil tap	0.031	0.591	0.651
Iteration of pencil tap	0.038	0.608	0.630
Iteration of pencil tap	0.044	0.646	0.583
Iteration of pencil tap	0.042	0.617	0.619
Eigenvalue	16.108		

Source: Authors' calculations

Table 7. Socio-emotional factor analysis

	Scoring coefficient	Loading	Uniqueness
Empathy - feelings	0.029	0.222	0.951
Empathy - help	0.041	0.240	0.942
Empathy - second help	0.035	0.226	0.949
Makes happy	0.041	0.257	0.934

	Scoring coefficient	Loading	Uniqueness
Makes unhappy	0.051	0.296	0.913
Pretend	0.027	0.239	0.943
Stay on task	0.130	0.659	0.565
Follow instructions	0.117	0.627	0.606
Plan ahead	0.087	0.559	0.687
Stop when asked	0.059	0.447	0.800
Rudely intrude	-0.058	-0.345	0.881
Keep working	0.090	0.585	0.658
Difficulties on disliked tasks	-0.040	-0.335	0.888
Explore new objects	0.078	0.529	0.720
Accept responsibility	0.097	0.596	0.645
Show consideration	0.104	0.608	0.630
Get along with other children	0.104	0.581	0.662
Offer help	0.114	0.640	0.590
Take turns	0.074	0.482	0.767
Share with peers	0.092	0.537	0.712
Easy transition adjustment	0.066	0.467	0.782
Settle down	0.038	0.254	0.935
Self-control	0.058	0.420	0.824
Kicks pushes pokes or hits	-0.054	-0.346	0.880
Upset when left	-0.035	-0.246	0.939
Sad or unhappy	-0.054	-0.364	0.867
Describe feelings	0.064	0.453	0.795
Eigenvalue	5.535		

Source: Authors' calculations

Table 8. Overall readiness factor analysis

	Scoring coefficient	Loading	Uniqueness
Iteration of naming body part	0.004	0.086	0.993
Iteration of naming body part	0.004	0.138	0.981
Iteration of naming body part	0.004	0.080	0.994
Iteration of naming body part	0.003	0.118	0.986
Iteration of naming body part	0.007	0.233	0.946
Vocabulary: eat	0.007	0.254	0.936
Vocabulary: animals	0.013	0.431	0.814
Ball on box	0.008	0.314	0.901
Ball under box	0.010	0.380	0.856
Ball in front of box	0.013	0.365	0.867
Ball in box	0.011	0.368	0.865
Draw a picture	0.006	0.199	0.960
Feel: picture book	0.003	0.170	0.971
Feel: Being read to	0.006	0.188	0.965
Feel: Learning to read	0.005	0.196	0.962
Feel: Learning letters	0.006	0.211	0.956
Feel: Writing	0.006	0.164	0.973
Iteration of letter recognition	0.013	0.546	0.701
Iteration of letter recognition	0.017	0.602	0.637
Iteration of letter recognition	0.025	0.636	0.596

	Scoring coefficient	Loading	Uniqueness
Iteration of letter recognition	0.030	0.666	0.557
Iteration of letter recognition	0.015	0.588	0.655
Iteration of letter recognition	0.023	0.655	0.571
Iteration of letter recognition	0.021	0.624	0.610
Iteration of letter recognition	0.025	0.651	0.576
Iteration of letter recognition	0.015	0.467	0.782
Iteration of letter recognition	0.015	0.511	0.739
Iteration of letter recognition	0.019	0.645	0.584
Iteration of letter recognition	0.019	0.611	0.626
Iteration of letter recognition	0.015	0.515	0.734
Iteration of letter recognition	0.022	0.645	0.583
Iteration of letter recognition	0.022	0.638	0.592
Iteration of letter recognition	0.010	0.505	0.745
Iteration of letter sound	0.017	0.587	0.655
Iteration of letter sound	0.021	0.572	0.673
Iteration of letter sound	0.023	0.566	0.680
Iteration of letter sound	0.020	0.587	0.656
Iteration of letter sound	0.016	0.529	0.721
Iteration of phoneme	0.006	0.266	0.929
Iteration of phoneme	0.009	0.413	0.829
Iteration of phoneme	0.002	0.084	0.993
Iteration of reading comprehension	0.008	0.260	0.932
Iteration of reading comprehension	0.009	0.326	0.894
Iteration of reading comprehension	0.013	0.387	0.850
Iteration of reading comprehension	0.007	0.291	0.915
Iteration of reading comprehension	0.014	0.466	0.783
Name writing	0.015	0.568	0.677
Copying X	0.014	0.486	0.763
Copying circle	0.009	0.303	0.908
Copying triangle	0.017	0.557	0.689
Read text correct direction	0.007	0.304	0.908
Know three letters	0.009	0.269	0.928
Know 10 letters	0.014	0.478	0.771
Write three letters	0.013	0.372	0.861
Write name	0.017	0.534	0.715
Write a word	0.013	0.445	0.802
Counting	0.021	0.675	0.544
Three bottle caps	0.016	0.507	0.743
Six bottle caps	0.018	0.622	0.613
Number recognition: 2	0.013	0.522	0.727
Number recognition: 6	0.021	0.615	0.621
Number recognition: 7	0.021	0.623	0.612
Number recognition: 10	0.021	0.616	0.620
Number recognition: 8	0.020	0.580	0.664
Number recognition: 5	0.017	0.557	0.690
Number recognition: 1	0.017	0.571	0.674
Number recognition: 4	0.022	0.619	0.617
Number recognition: 3	0.018	0.587	0.656
Number recognition: 9	0.025	0.647	0.582
Larger 3 or 5	0.006	0.349	0.879
Larger 8 or 6	0.013	0.484	0.766
Smaller 4 or 7	0.013	0.512	0.737
Two plus one bottle caps	0.012	0.389	0.849
Three plus two bottle caps	0.015	0.498	0.752
Four plus two bottle caps	0.022	0.595	0.646

	Scoring coefficient	Loading	Uniqueness
Identify three shapes	0.010	0.303	0.908
Identify three colors	0.006	0.227	0.948
Count one to 10	0.010	0.367	0.865
Relative size	0.006	0.195	0.962
Times of day	0.004	0.195	0.962
Days	0.011	0.319	0.898
Relative weight	0.008	0.160	0.974
Number comparison	0.011	0.372	0.861
Iteration of head/knees/shoulders/toes	-0.009	-0.567	0.679
Iteration of head/knees/shoulders/toes	0.018	0.631	0.602
Iteration of head/knees/shoulders/toes	0.017	0.618	0.618
Iteration of head/knees/shoulders/toes	0.022	0.628	0.605
Iteration of head/knees/shoulders/toes	0.020	0.616	0.621
Iteration of head/knees/shoulders/toes	0.022	0.626	0.608
Iteration of head/knees/shoulders/toes	0.022	0.622	0.613
Iteration of head/knees/shoulders/toes	0.024	0.634	0.599
Iteration of head/knees/shoulders/toes	0.025	0.649	0.579
Iteration of head/knees/shoulders/toes	0.027	0.648	0.580
Iteration of head/knees/shoulders/toes	0.020	0.641	0.589
Iteration of head/knees/shoulders/toes	0.029	0.663	0.561
Iteration of head/knees/shoulders/toes	0.026	0.657	0.568
Iteration of head/knees/shoulders/toes	0.023	0.658	0.567
Iteration of head/knees/shoulders/toes	0.023	0.652	0.574
Iteration of head/knees/shoulders/toes	0.015	0.606	0.633
Forward digit span (two)	0.005	0.138	0.981
Forward digit span (three)	0.007	0.255	0.935
Forward digit span (four)	0.008	0.349	0.878
Forward digit span (five)	0.007	0.321	0.897
Iteration of pencil tap	0.013	0.461	0.787
Iteration of pencil tap	0.018	0.555	0.692
Iteration of pencil tap	0.018	0.562	0.684
Iteration of pencil tap	0.015	0.519	0.730
Iteration of pencil tap	0.020	0.549	0.698
Iteration of pencil tap	0.019	0.538	0.710
Iteration of pencil tap	0.018	0.535	0.713
Iteration of pencil tap	0.018	0.518	0.732
Iteration of pencil tap	0.013	0.467	0.782
Iteration of pencil tap	0.017	0.497	0.753
Iteration of pencil tap	0.015	0.526	0.724
Iteration of pencil tap	0.017	0.518	0.732
Iteration of pencil tap	0.014	0.498	0.752
Iteration of pencil tap	0.019	0.539	0.710
Iteration of pencil tap	0.019	0.556	0.691
Iteration of pencil tap	0.018	0.537	0.712
Empathy - feelings	0.008	0.320	0.897
Empathy - help	0.010	0.280	0.921
Empathy - second help	0.005	0.267	0.929
Makes happy	0.010	0.346	0.880
Makes unhappy	0.012	0.362	0.869
Pretend	0.003	0.087	0.992
Stay on task	0.018	0.456	0.792
Follow instructions	0.014	0.360	0.870
Plan ahead	0.008	0.297	0.911
Stop when asked	0.005	0.159	0.975
Rudely intrude	-0.004	-0.139	0.981

	Scoring coefficient	Loading	Uniqueness
Keep working	0.010	0.306	0.906
Difficulties on disliked tasks	-0.005	-0.195	0.962
Explore new objects	0.008	0.284	0.920
Accept responsibility	0.009	0.283	0.920
Show consideration	0.008	0.238	0.943
Get along with other children	0.008	0.225	0.949
Offer help	0.010	0.284	0.919
Take turns	0.004	0.146	0.979
Share with peers	0.006	0.210	0.956
Easy transition adjustment	0.005	0.193	0.963
Settle down	0.002	0.063	0.996
Self-control	0.006	0.185	0.966
Kicks pushes pokes or hits	-0.006	-0.201	0.960
Upset when left	-0.004	-0.116	0.987
Sad or unhappy	-0.004	-0.076	0.994
Describe feelings	0.008	0.243	0.941
Eigenvalue	30.713		

Source: Authors' calculations

Table 9. Home stimulation factor analysis

	Scoring coefficient	Loading	Uniqueness
Books or picture books	0.357	0.618	0.617
Read to in last 7 days	0.308	0.568	0.660
Sung to last 7 days	0.158	0.342	0.847
Played with in last 7 days	0.070	0.161	0.967
Told stories last 7 days	0.245	0.495	0.753
Eigenvalue	1.092		

Source: Authors' calculations

Table 10. Environment factor analysis

	Scoring coefficient	Loading	Uniqueness
Class enrollment	0.052	0.089	0.992
Sufficient hall space - present	0.057	0.212	0.955
Sufficient hall space - enrolled	0.080	0.200	0.960
Seats and desk	0.011	0.040	0.998
Yard space for play	0.165	0.545	0.703
Games or equipment - major motor	0.202	0.579	0.665
Soap and water	0.204	0.590	0.652
Children wash with soap and water	0.235	0.646	0.583
Clean appropriate children's toilets	0.133	0.547	0.701
Gender segregated toilets	0.065	0.319	0.898
Uneven floors	-0.094	-0.337	0.886
Broken chairs or tables	-0.056	-0.261	0.932
Ceiling leak or holes	-0.057	-0.219	0.952
Broken windows or doors	-0.065	-0.284	0.919
Inadequate light	-0.085	-0.324	0.895

	Scoring coefficient	Loading	Uniqueness
Inadequate ventilation	-0.089	-0.361	0.870
Rocky fields trash or pits	-0.086	-0.359	0.871
Other hazards	-0.115	-0.467	0.782
Eigenvalues	2.787		

Source: Authors' calculations

Table 11. Attitudes factor analysis

	Scoring coefficient	Loading	Uniqueness
Satisfied with job	0.174	0.378	0.857
Receive adequate support from director	0.277	0.537	0.712
Overwhelmed	-0.131	-0.297	0.912
Adequate resources from school	0.308	0.571	0.674
Pre-primary teacher valued	0.227	0.471	0.778
Pre-primary teacher important job	0.069	0.160	0.974
Have training to be effective pre-primary teacher	0.114	0.256	0.935
Understand new education system	0.064	0.142	0.980
Eigenvalue	1.178		

Source: Authors' calculations

Table 12. Teaching practices factor analysis

	Scoring coefficient	Loading	Uniqueness
Math skills practices	0.057	0.257	0.934
Reading skill practices	0.052	0.245	0.940
Expressive language skills practices	0.198	0.610	0.628
Book or story reading	0.083	0.332	0.890
Telling stories	0.080	0.317	0.899
Micro motor skills practices	0.124	0.465	0.783
Singing or music activities	0.098	0.375	0.859
Major motor skills activities	0.111	0.425	0.819
Modify bad behavior	0.140	0.522	0.728
Oral praise	0.165	0.565	0.681
Children on task throughout	0.174	0.576	0.668
Children wait 10 or more minutes	-0.140	-0.489	0.761
Children supervised	0.076	0.310	0.904
Teacher works individually	0.095	0.389	0.849
Teacher tracks development	0.128	0.451	0.797
Eigenvalue	2.859		

Source: Authors' calculations

Table 13. Materials factor analysis

	Scoring coefficient	Loading	Uniqueness
Portfolio	0.120	0.479	0.771
Textbook	0.012	0.031	0.999
Writing utensils	0.098	0.398	0.841
Art	0.188	0.595	0.646
Fantasy play	0.149	0.557	0.689
Blocks	0.160	0.567	0.678
Educational toys or math materials	0.186	0.617	0.620
Storybooks	0.170	0.584	0.659
Activities hall essentials	0.118	0.478	0.772
Books in Arabic	0.210	0.637	0.594
Books in English	0.065	0.296	0.913
Eigenvalue	2.818		

Source: Authors' calculations

Table 14. Adherence factor analysis

	Scoring coefficient	Loading	Uniqueness
Use education 2.0	0.436	0.734	0.461
Preparation matches lesson	0.372	0.700	0.509
Math window followed	0.069	0.235	0.945
Arabic window followed	0.119	0.359	0.871
English window followed	0.034	0.141	0.980
Other language window followed	0.023	0.049	0.998
Multidisciplinary window followed	0.100	0.302	0.909
Eigenvalue	1.328		

Source: Authors' calculations