Challenges of monolingual and multilingual education: cognition, numeracy, and literacy skills in primary school children in India

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Multilingualism and Multiliteracy: Raising Learning Outcomes in challenging contexts in primary schools across India (May 2016 – April 2020)

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The trigger

Problem: Causes of low learning outcomes of primary school children in multilingual India

Context: Advantages to being bilingual or multilingual in attention and learning skills

Research question: Why do some children in India not benefit from being bilingual or multilingual to the same degree as children in other contexts?
Background

Bilingualism has been shown to have beneficial effects on:

Cognitive control (e.g. Bialystok et al 2008; 2011)

a. working memory

b. Cognitive flexibility, allocation of attention resources and inhibition of inappropriate/incorrect response biases

Delay of dementia and cognitive decline in the elderly (Alladi et al 2013; 2014)

Creativity (Kharkhurin 2012, for adults; Leikin 2012, for children)

Creativity as a measure of *divergent* thinking: subconscious process involving a broad search for information and the generation of numerous alternative answers or solutions to a problem ( Guildford 1967)
• Reports from developing countries suggest that 221 million children are educated in a language they do not speak at home

→ poor education quality, drop-out rates, low literacy outcomes (Cummins 2009)

→ Many EAL children in the UK are monoliterate in English.
• **Mother-tongue literacy** for children attending schooling in L2 has revealed benefits in:

• The **strength** of the minority language in its mental (conceptual and processing) competition with the majority language

• Working memory

• Efficient transfer of basic and higher level literacy skills

Previous findings

- Biliteracy effects on cognitive and language abilities in different groups of bilingual children with varied SES: **strongest cognitive advantage** in the group with **literacy skills in both the MT and the L2**.

  (Dosi, Papadopoulou & Tsimipi, 2016)

- Bilingual children with bilingual education including MT literacy **outperform** bilinguals educated only in the L2 in the cognitive function of **updating**.

  (Marinis, Bongartz and Tsimipli (under review))
Although multilingualism is the norm in India, level of proficiency in the home language varies primarily as a function of whether education includes the home language or not. (Panda & Mohanty 2013; ASER 2014)
Background information on learning outcomes in Indian schools

• ASER studies conducted with 600,000 children across India established that more than half of all children in Standard 5 could not read a Standard 2 level text fluently, and nearly half of them could not solve Standard 2 level subtraction task.

• Low literacy and numeracy can limit other important capabilities, e.g., critical thinking and problem solving

• Low educational achievement may lead to dropping out of school

• Teachers and schools in India are also well aware of these facts

• High dropout rate in schools affecting girls more than boys (Unesco’s Education Report, 2015; Annual Status of Education Report Pratham, 2014).

• The gap between state and private schools is increasing every year.
More than one thousand indigenous languages belonging to four major language families (Indo-Aryan and Dravidian being spoken by the majority of the population followed by Austroasiatic and Sino-Tibetan languages).

In our project, the languages of assessment tools are: Hindi, Telugu and English, although other home languages are included in the assessment of one cognitive task.
The research question

Why don’t some children in India benefit from being bilingual or multilingual to the same degree as children in other contexts?
To answer the question, more questions to ask:

Is there a link between basic literacy and numeracy levels and MT education provision on the other?

What is the *cognitive* profile of Indian children educated in challenging contexts? Are memory and attention skills affected by *educational* elements and how does *demographic* information (parental literacy and educational levels, home resources) affect them further?

Are numeracy skills, mathematical ability and math anxiety related? Is the link between maths anxiety and the development of numeracy skills more evident in girls than boys (thus leading to higher drop-out rates for girls)?
Questions (cntd.)

• Is MT literacy (in Multilingual Education) a positive factor for critical thinking and problem solving skills?

• Are critical thinking and problem solving skills in the medium of instruction transferrable in the child’s use of English for similar tasks?

• What is the relative contribution of lack of MT education to low education levels in comparison with socioeconomic and geographical factors affecting educational outcomes for school children in urban slums and remote rural areas?

• To what extent do factors related to teaching methods and teacher training affect learning outcomes in literacy and numeracy?
RESEARCH FOCUS

Learning outcomes (in literacy, numeracy and cognitive skills) in challenging contexts

Educational variables
- Mother-tongue education and the role of English
- Linguistic Diversity & Multilingualism in the classroom
- Teacher qualification and school pedagogies

External variables
- Gender inequalities, low socio-economic status, geographical disparity
Impact

• Capacity-building: at least 15 junior researchers working on the project at the moment; trained and actively engaged in research ethics, design, methods, data entry and analysis.

• Policy-makers, educational charities, practitioners and teachers actively engaged; upcoming dissemination event in Delhi (13-14/7/2018).
1800 children from low SES Primary school (Standards 4 and 5) in rural, urban and slum school settings across 3 States: Bihar, Hyderabad, New Delhi.

**Research Design**

Comparative study employing qualitative and quantitative methods.

- **Baseline Task**: Non-verbal IQ
- **Experimental tasks**: (Basic literacy and numeracy, Critical thinking, Problem-solving, Memory and Cognitive tasks)
- **Higher Literacy skills**: Narrative Retelling
- **Mixed-methods data analysis**
- **School Surveys, Class observations, Child questionnaires**

Headteachers, Math and Language Teachers.
Geographical and social factors

- Urban (Delhi, Hyderabad) vs. Rural (Bihar)
- Bihar is one of the less developed and educationally disadvantaged areas of India (Tsujita, 2009, Unesco EFA Report).
- Urban areas: Children living in slum vs. non-slum areas
- Urban slums are settlements with inadequate access to safe water, sanitation and infrastructure, poor structural quality of housing, overcrowding and insecure residential status.
- Urban slums (where 17% of urban citizens in India live) include a large number of internal migrants who may speak other MTs or varieties of the regional language.
Urban slums

• School attendance rates for children living in Delhi slums is around 54% compared to attendance ratios in Delhi schools overall which was 90% in 2004 (Tsujita, 2009). Currently, attendance ratios are higher.

• Around 73% of slum children attending Std I in Delhi schools are over-aged (school capacity and administrative issues)

➔ Inequalities in education provision
The project’s design

- Short longitudinal design

- Assessing the development of language, literacy, numeracy, cognitive functions, critical thinking, and problem solving over two years in the same groups of children who differ in
  (i) MT education/literacy provision,
  (ii) in education sites: remote and non-remote rural India and urban slum vs. non-slum
Innovations

- a) large range of tasks directly assessing children’s cognition and metacognition and external factors (e.g., SES, geographic factors, teacher training and qualifications) on children’s learning outcomes.
- b) the recruitment of a large number of children across three different states, which makes the study representative and
- c) the development of language, literacy, numeracy and critical thinking tasks in Hindi and Telugu.
Battery of Tasks: 1. Surveys and questionnaires

- *Language* questionnaire – Child (Demographic info, Language use info, socioeconomic variables)

- *Headteacher* questionnaire (demographics of the school, school curriculum and instruction, teaching practice and attitude)

- (Maths & Language) *Teacher* questionnaire: training, qualifications, language attitude (e.g. translanguaging), teaching and learning methods and materials

- *Classroom observation* tool (Teaching environment, observation of teaching activity, teaching content and strategies, teaching practices and good practice indicators)
The battery of tasks: 2. Cognitive

- Raven’s Progressive matrices – non-verbal IQ
- Flankers – inhibitory control (EF task) – non-verbal
- N-back – Updating (complex working memory) – non-verbal
- Semantic fluency - verbal
Semantic fluency

- a measure of verbal functioning and cognitive flexibility. (Memisevic et al., 2017)

- In this task, children have to name as many members of a specific semantic category in 1 minute.

<table>
<thead>
<tr>
<th>Category</th>
<th>Home language (Day 1)</th>
<th>School language (Day 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living</td>
<td>Birds</td>
<td>Animals</td>
</tr>
<tr>
<td>Non-living</td>
<td>Household objects</td>
<td>Fruit</td>
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</tbody>
</table>
Raven’s Progressive Matrices

• To measure the children’s general nonverbal abilities.

• 36 items administered in 3 sets (12 items in each)
Battery of tasks: 3. Literacy

- ASER (Basic literacy):
  Letter naming, single word reading, reading of sentences, reading of passages and a couple of comprehension questions.
  - Administered in the school language and English.

- Narrative retelling (measure of ‘higher’ literacy, complex language, lexical diversity) – *Multilingual Assessment Instrument for Narratives - MAIN*
  (Gagarina et al, 2012; Gagarina, Klop, Tsimpili & Walters, 2016)
Battery of Tasks: 3. Numeracy

- To examine children’s numerical understanding - their critical and problem solving skills.

1. ASER (basic) Numeracy Test
2. Maths Word Problem Tests and Meta-cognitive tasks
3. Maths Anxiety Scale Test

- Are there gender differences in any of the above?
- Is there a correlation between any of the above and Raven’s?
Basic Numeracy skills (ASER): Subtraction and Division

- Subtraction and Division tasks have a better discriminant value compared to Addition and Multiplication.
- Division is the hardest of all four.

Subtraction

<p>| | |</p>
<table>
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<tr>
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<td>41</td>
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<td>84</td>
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<td>- 36</td>
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<td>31</td>
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<td>- 37</td>
<td>- 13</td>
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<td>45</td>
<td>53</td>
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<td>- 18</td>
<td>- 24</td>
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Division

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<tr>
<td>7</td>
<td>928</td>
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<tr>
<td>6</td>
<td>769</td>
</tr>
<tr>
<td>8</td>
<td>987</td>
</tr>
<tr>
<td>4</td>
<td>519</td>
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</tbody>
</table>
Mathematical skills: Word problems (Total: 6)

Question 1:
Sita stacks the boxes (image 1) in the corner of the room. All boxes are the same size. How many boxes has she used, in total? [Please tick/circle]

- A 25
- B 19
- C 18
- D 13

• Word-problems require good reading comprehension levels (Bjork & Bowyer-Crane, 2012).
• In our dataset, most children asked the experimenter to present the word problem orally in the regional language (Hindi or Telugu).
QUESTION 1

Here is how Nita solves two addition problems.

\[
\begin{align*}
19 & \quad 17 \\
+13 & \quad +9 \\
\hline
212 & \quad 116
\end{align*}
\]

Do you think that the problems are solved correctly? If not, why is Nita wrong in her responses?

**Answer:**

1. Nita doesn’t know how to add numbers
2. Nita doesn’t know place value and carry forward of values
3. Nita was not attentive
4. I don’t know
5. Any other
• The task assesses *monitoring* mathematical problem-solving skills, perspective-taking, and postdiction judgements (i.e. identification of the error/wrong strategy which led to the incorrect solution)

(cf. Jakobse & Harskambe, 2012)
### Math anxiety scale (Devine et al, 2012)

<table>
<thead>
<tr>
<th>1.9 Anxiety Scale</th>
<th>Low anxiety</th>
<th>Some anxiety</th>
<th>Moderate anxiety</th>
<th>Quite a bit of anxiety</th>
<th>High anxiety</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Having to complete a worksheet by yourself.</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😠</td>
<td>😠</td>
</tr>
<tr>
<td>2. Thinking about a maths test the day before you take it.</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😠</td>
<td>😠</td>
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<tr>
<td>3. Watching the teacher work out a maths problem on the board.</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😠</td>
<td>😠</td>
</tr>
<tr>
<td>4. Taking a maths test.</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😠</td>
<td>😠</td>
</tr>
<tr>
<td>5. Being given maths homework with lots of difficult questions that you have to hand in the next day.</td>
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<td>😊</td>
<td>😊</td>
<td>😠</td>
<td>😠</td>
</tr>
<tr>
<td>6. Listening to the teacher talk for a long time in maths.</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😠</td>
<td>😠</td>
</tr>
<tr>
<td>7. Listening to another child in your class explain a maths problem.</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😠</td>
<td>😠</td>
</tr>
<tr>
<td>8. Finding out you are going to have a surprise maths quiz when you start your maths lesson.</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😠</td>
<td>😠</td>
</tr>
<tr>
<td>9. Starting a new topic in maths.</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😠</td>
<td>😠</td>
</tr>
</tbody>
</table>
Participants (so far)

- Bi/Multilingual children (c. 900 children) in Delhi and Hyderabad in slum and non-slum areas

- Short longitudinal design -
  - Children in Std 4- to be tested again after 1 year in Std 5

- Differences between Delhi and Hyderabad:

- Delhi government schools are now all English-medium; in Hyderabad, there are English-medium and Telugu-medium schools.

→ Between 60 and 70% of children in both sites are reported to have a home language different from the medium of instruction.
Preliminary data from the Delhi site (Minati Panda’s research team; JNU)

Participants: Bi/multilingual Children in Year 4

<table>
<thead>
<tr>
<th>Groups</th>
<th>Boys</th>
<th>Girls</th>
<th>Total (N=344)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slum</td>
<td>43</td>
<td>80</td>
<td>123</td>
</tr>
<tr>
<td>Non-slum</td>
<td>104</td>
<td>117</td>
<td>221</td>
</tr>
</tbody>
</table>

- Between group comparisons (2-way ANOVA)
  - Slum vs. non-slum; Boys vs. girls

- Correlation analyses
  - To assess the relationship between variables.
Preliminary findings

Math Anxiety score:
Ratings on a scale of 1-5 (1-Low anxiety; 5-High anxiety)

- No main effect of group (school type): $F(1,340)=0.015$, $p=0.90$

- No main effect of gender: $F(1,340)=0.17$, $p=0.67$

- No interaction of group x gender: $F(1,340)=2.87$, $p=0.09$. 
Math anxiety scores

• When children were asked about how they would feel if another student performs better in the class, many replied they would be happy, or everybody should clap etc.

• It seems that children are quite young to feel math anxiety OR that the schools we tested in (low SES) do not foster competition and comparisons.

• Child participants in our study may struggle with comprehension, regular attendance etc.

• Teacher and parent expectations could also be lower for similar reasons.
Number Recognition task

-- This is part of ASER’s basic numeracy task: Children are asked to name single and double-digit numbers – ‘threshold test’
-- Scores are rather low for Std IV children. However, division vs. subtraction are not of the same level of difficulty.
Numeracy

- For the numeracy skills, the scores of number recognition and subtraction & division were averaged and combined.

- No main effect of group (school type): $F(1,340)= 2.19, p=0.14$

- No Main effect of gender: $F(1,340)= 1.87, p=0.17$

- No interaction of group x gender: $F(1,340)=0.48, p=0.48$. 

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Math word problems task

Teachers usually have to read out the word problems $2/3$ times before asking children to solve them.

Word problems were orally presented to the children in our study.

Gender difference

Tendency for an advantage of the slum group?
Although these children seem to struggle with subtraction and division, the development of mathematical meta-cognition and oral heuristics appears to be better. Life experience?
Mathematical ability

- Scores from math word problems and metamaths task were averaged and combined.

- No main effect of group (school type): $F(1,340)=0.001$, $p=0.97$

- Main effect of gender: $F(1,340)=8.17$, $p=0.013^*$

- No interaction of group x gender: $F(1,340)=0.05$, $p=0.81$. 
Raven’s progressive matrices

- **Main effect of group** (school type): $F(1,296)= 5.04, p=0.025^*$

**Main effect of gender**: $F(1,296)= 3.98, p=0.047^*$

No Group x Gender interaction: $F(1,296)=0.32, p=0.56$. 
Correlation Analyses

- No correlation between numeracy skills and math anxiety \((r=-0.055, N=344, p=0.309)\).

- No correlation between mathematical ability and math anxiety \((r=0.27, N=344, p=0.617)\).

- This probably suggests that the children are too young or not schooled in a context where competition or high expectations would foster math anxiety.

- Moderate positive correlation between mathematical ability and numeracy skills \((r=0.57, N=344, p<0.01)\).
Correlation analyses (cntd.)

- Are numeracy and mathematical ability related to cognitive ability (Raven’s scores)?

  ➔ a weak positive correlation between mathematical ability and Raven’s scores ($r=0.16$, $N=195$, $p=0.019$) and between numeracy skills and Raven’s scores ($r=0.27$, $N=195$, $p<0.01$).
A multiple regression analysis was carried out to test if the mathematical ability and numeracy skills **significantly predict** the cognitive performance on Raven’s matrices.

A significant regression equation was found \([F (2,192)=4.407, p=0.013]\) with an \(R^2\) of 0.044.

→ Mathematical ability and numeracy skills are **not** significant predictors of cognitive performance.
Discussion

- Oral mathematical skills (word problems and meta-maths) appear to be less problematic for these children than pen and paper tasks (division and subtraction).

- The numeracy data need to be analysed in relation to children's background data and literacy levels, narrative skills and teacher/pedagogy data.

What is the role of life experience in children living in challenging contexts? The opportunity to engage with quantity assessments and relating these quantities to money or to other quantities is higher among children from poor families as parents often require children's support for handling everyday activities including buying and selling in markets.

(cf. Stillman & Galbraith, 1998; Schoenfeld, 1996)
Open questions

• The urban poor may have an added advantage of dealing with quantity phenomena, the relationships and patterns in multilingual and multi-communicative contexts because of frequent migration of people from different parts of the country to slum areas.

• Would this predict better problem-solving skills for children in slum areas?

• All questions are still open.

• A more general question about the data from challenging educational contexts: Could life experience in the urban poor of the Global South compensate for gaps in the schooling system?
The Delhi team - JNU

Prof. Minati Panda

Nainy Rao  Shitika Chowdhary  Shalini Yadav  Yashika Chandna
The Patna and Hyderabad teams:

**Patna team:**
- Dr Lina Mukhopadhyay (EFL-U)
- Shravasti Chakrabarti
- Kankan Das
- Vasim Tamboli

**Hyderabad team:**
- Prof. Suvarna Alladi (NIMHANS)
- Abhigna Reddy
- Anu Nagalakshmi K
- Deepa BR,
- Dedeepya B,
- Joshua Reddy,
- Jyothi M.
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