Are Teachers and Learning Software Complements or Substitutes?

Evidence from a Randomized Experiment in El Salvador

Konstantin Büchel, Martina Jakob, Christoph Kühnhanss, Daniel Steffen, Aymo Brunetti

Department of Economics & Institute for Sociology, University of Bern

November 12, 2018
Outline

- Motivation & context of the study
- Literature & contribution
- CAL intervention in El Salvador
- Study design
- Next steps
1. Impressive increases in primary education enrollment in developing countries

Primary education net enrollment rate

Data source: World Bank
Motivation

Two stylized facts

1 Poor learning outcomes

(a) El Salvador (Morazán), N=3461  
(b): Switzerland (Bern), N=164

Figure: Bar graphs (with 80% confidence intervals) show share of correct answers to 2nd grade math questions, Source: own data.
Motivation

Two stylized facts

2 Poor learning outcomes

\[ c. \ 8 \div 2 = \underline{____} \]

**Figure:** Bar graphs show share of correct answers to 2\textsuperscript{nd} grade math questions, Source: own data.
Motivation
What happens in the classroom?

1. Children spend relatively little time in school
   - Only morning or afternoon classes in El Salvador
   - Cancellation of many school lessons
   → 1000 unannounced visits: 26% of all lessons are not held!

2. Low teaching quality
   - Large and heterogeneous classes
   - Outdated pedagogy focusing on memorization and reproduction
   - Low qualification and/or motivation of teachers
Motivation

What happens in the classroom?

1. Children spend relatively little time in school
   - Only morning or afternoon classes in El Salvador
   - Cancellation of many school lessons
   → 1000 unannounced visits: 26% of all lessons are not held!

2. Low teaching quality
   - Large and heterogeneous classes
   - Outdated pedagogy focusing on memorization and reproduction
   - Low qualification and/or motivation of teachers
Motivation
What happens in the classroom?

1. Children spend relatively little time in school
   - Only morning or afternoon classes in El Salvador
   - Cancellation of many school lessons
     → 1000 unannounced visits: 26% of all lessons are not held!

2. Low teaching quality
   - Large and heterogeneous classes
   - Outdated pedagogy focusing on memorization and reproduction
   - Low qualification and/or motivation of teachers
Motivation
What happens in the classroom?

How can these problems be addressed?
Motivation
What happens in the classroom?

→ How can these problems be addressed?
Motivation

What can be done?

1. Expand school time

2. Computer-assisted learning (CAL)
   - Self-paced learning
   - Start at a very low level
   - Less sensitive to teacher quality
Related Literature & Contribution

Previous literature mainly focuses on Asia
- e.g. Banerjee et al. (2007), Muralidharan et al. (2017) in India
- e.g. Yang et al. (2012), Mo et al. (2014) in China

Our contribution
- What is the main causal channel? Are learning gains mainly attributable to...
  - a. ... use of a software
  - b. ... additional lessons?
- How can CAL-lessons be implemented cost-effectively?
  - I.e. Are teachers and software substitutes or complements?
- External validity: New software and context
Related Literature & Contribution

Previous literature mainly focuses on Asia
  - e.g. Banerjee et al. (2007), Muralidharan et al. (2017) in India
  - e.g. Yang et al. (2012), Mo et al. (2014) in China

Our contribution
  - What is the main causal channel? Are learning gains mainly attributable to...
    - a. ... use of a software
    - b. ... additional lessons?
  - How can CAL-lessons be implemented cost-effectively?
    - I.e. Are teachers and software substitutes or complements?
  - External validity: New software and context
Related Literature & Contribution

Previous literature mainly focuses on Asia
- e.g. Banerjee et al. (2007), Muralidharan et al. (2017) in India
- e.g. Yang et al. (2012), Mo et al. (2014) in China

Our contribution
- What is the main causal channel? Are learning gains mainly attributable to...
  - a. ... use of a software
  - b. ... additional lessons?
- How can CAL-lessons be implemented cost-effectively?
  - I.e. Are teachers and software substitutes or complements?
- External validity: New software and context
Related Literature & Contribution

Previous literature mainly focuses on Asia
- e.g. Banerjee et al. (2007), Muralidharan et al. (2017) in India
- e.g. Yang et al. (2012), Mo et al. (2014) in China

Our contribution
- What is the main causal channel? Are learning gains mainly attributable to...
  - a. ... use of a software
  - b. ... additional lessons?
- How can CAL-lessons be implemented cost-effectively?
  - I.e. Are teachers and software substitutes or complements?
- External validity: New software and context
Ministry of Education in El Salvador plans to ...  
- ...expand school time  
- ...provide a computer for every child

NGO Consciente picks up the thread and plans to ...  
- ...offer additional and computer-based math lessons  
- ...investigate the impact of project scientifically

University of Bern becomes partner of Consciente and ...  
- ...designs a RCT-study  
- ...evaluates the project
CAL-Impact Intervention in a Nutshell

Paso 3: Evaluación Aleatoria

Treatment 1
2 x 90min / Week
~800 Students

Treatment 2
2 x 90min / Week
~800 Students

Treatment 3
2 x 90min / Week
~800 Students

En coordinación con:
University of Bern
Premiado por:
ETH Zurich
SDC
Timeline

Baseline Test & Survey

Start of intervention

Control Group: Regular Math Classes in the Morning (2x 90 min per week)

Treatment 1: Additional Math Classes without Computers (2x 90 min per week)

Treatment 2: Additional CAL-Classes with Supervisor (2x 90 min per week)

Treatment 3: Additional CAL-Classes with Teachers (2x 90 min per week)

Endline Test

Feb 2018

Apr 2018

Oct 2018

Start of intervention

Control Group: Regular Math Classes in the Morning (2x 90 min per week)

Treatment 1: Additional Math Classes without Computers (2x 90 min per week)

Treatment 2: Additional CAL-Classes with Supervisor (2x 90 min per week)

Treatment 3: Additional CAL-Classes with Teachers (2x 90 min per week)
Figure: Map of El Salvador (red: San Salvador, grey: Morazán)
Study Design
Preselection and Randomization

Figure: All schools of Morazán

Figure: Preselection of schools in Morazán
Study Design

Estimation Equation

\[ MS_{ics}^{Oct} = \alpha + \beta_1 T_{1ics} + \beta_2 T_{2ics} + \beta_3 T_{3ics} + \delta MS_{ics}^{Feb} + \gamma X_{ics}^{Feb} + \lambda S + \mu Strata + \epsilon_{ics} \]

1. Do additional CAL-lessons have a causal impact on numeracy skills?

\[ \beta_3 : \text{ Increase in learning outcomes attributable to CAL-lessons conducted by a teacher} \]

2. What is the main causal channel?

\[ \beta_3 - \beta_1 \geq 0? : \text{ Can the increase in learning outcomes be attributed to the additional lessons and/or the use of software?} \]

3. How can CAL-lessons be implemented cost-effectively?

\[ \frac{\beta_3}{\beta_2} \geq \frac{\text{cost}(T3)}{\text{cost}(T2)}? : \text{ Are software and teaching skills (strongly) complementary?} \]
Study Design

Estimation Equation

\[
MS_{ics}^{Oct} = \alpha + \beta_1 T_{1ics} + \beta_2 T_{2ics} + \beta_3 T_{3ics} + \delta MS_{ics}^{Feb} + \gamma X_{ics}^{Feb} + \lambda S + \mu Strata + \epsilon_{ics}
\]

1. Do additional CAL-lessons have a causal impact on numeracy skills?

   \( \beta_3 \): Increase in learning outcomes attributable to CAL-lessons conducted by a teacher

2. What is the main causal channel?

   \( \beta_3 - \beta_1 \geq 0 ? \): Can the increase in learning outcomes be attributed to the additional lessons and/or the use of software?

3. How can CAL-lessons be implemented cost-effectively?

   \( \frac{\beta_3}{\beta_2} \geq \frac{\text{cost}(T3)}{\text{cost}(T2)} ? \): Are software and teaching skills (strongly) complementary?
Study Design

Estimation Equation

\[ MS_{ics}^{Oct} = \alpha + \beta_1 T_{1ics} + \beta_2 T_{2ics} + \beta_3 T_{3ics} + \delta MS_{ics}^{Feb} + \gamma X_{ics}^{Feb} + \lambda S + \mu Strata + \epsilon_{ics} \]

1. Do additional CAL-lessons have a causal impact on numeracy skills?
   \( \beta_3 \): Increase in learning outcomes attributable to CAL-lessons conducted by a teacher

2. What is the main causal channel?
   \( \beta_3 - \beta_1 \geq 0 \): Can the increase in learning outcomes be attributed to the additional lessons and/or the use of software?

3. How can CAL-lessons be implemented cost-effectively?
   \( \frac{\beta_3}{\beta_2} \geq \frac{\text{cost}(T_3)}{\text{cost}(T_2)} \): Are software and teaching skills (strongly) complementary?
Study Design

Estimation Equation

\[ MS^{Oct}_{ics} = \alpha + \beta_1 T1_{ics} + \beta_2 T2_{ics} + \beta_3 T3_{ics} + \delta MS^{Feb}_{ics} + \gamma X^{Feb}_{ics} + \lambda S + \mu_{Strata} + \epsilon_{ics} \]

1. Do additional CAL-lessons have a causal impact on numeracy skills?
   \( \beta_3 \): Increase in learning outcomes attributable to CAL-lessons conducted by a teacher

2. What is the main causal channel?
   \( \beta_3 - \beta_1 \geq 0 \): Can the increase in learning outcomes be attributed to the additional lessons and/or the use of software?

3. How can CAL-lessons be implemented cost-effectively?
   \( \frac{\beta_3}{\beta_2} \geq \frac{\text{cost}(T3)}{\text{cost}(T2)} \): Are software and teaching skills (strongly) complementary?
Next steps

- Digitizing endline test (⅓ done)
- Evaluation of the intervention and final results
  - Effect on math skills
  - Effect on attendance