WPS7954

Policy Research Working Paper 7954

Can Solar Lanterns Improve Youth Academic Performance?

Experimental Evidence from Bangladesh

Yuya Kudo
Abu S. Shonchoy
Kazushi Takahashi

WORLD BANK GROUP
Development Economics Vice Presidency
Operations and Strategy Team
January 2017

Policy Research Working Paper 7954

Abstract

This study conducted an experimental intervention in unelectrified areas of northern Bangladesh to investigate the effectiveness of solar products in improving children's educational achievement. It found that treated households substituted solar lanterns for kerosene-based lighting products, helping to decrease total household expenditure. Solar lanterns increased the children's home-study hours, particularly at night and before exams. The solar lanterns initially led to an increase in school attendance, but this effect diminished over time. However, the increased study hours and initial improvement in school attendance did not translate into improved academic performance. Varying the number of solar products within the treated households did not alter these results. Analyses that exploited the school grade treatment intensity also provided no evidence suggesting that spillover effects explained the "no academic performance effects." These findings suggest that improving the home-study environment solely through the provision of solar products may have a limited impact on children's educational achievement.

This paper is a product of the Operations and Strategy Team, Development Economics Vice Presidency. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org.
The authors may be contacted at Yuya_Kudo@ide.go.jp.

Can Solar Lanterns Improve Youth Academic Performance? Experimental Evidence from Bangladesh

Yuya Kudo* Abu S. Shonchoy Kazushi Takahashi

Keywords: Bangladesh, clean and renewable energy, education, randomized control trials, solar light

JEL classification: I25, O13, Q42

*Yuya Kudo (corresponding author) is a research fellow at the Institute of Developing Economies, JETRO (IDE-JETRO), Chiba, Japan; his email address is Yuya_Kudo@ide.go.jp. Abu S. Shonchoy is a research fellow at the IDE-JETRO; his email address is parves.shonchoy@gmail.com. Kazushi Takahashi is an associate professor at Sophia University, Tokyo, Japan; his email address is kazushi.takahashi@sophia.ac.jp. This work was supported by a research grant provided by the IDE-JETRO. This work also received generous contributions to procurement of solar devices from the BRAC and social business funds provided by Daiwa Securities through an online technology market operated by Kopernik. We thank an editor, three anonymous referees, Sudhir Chandra Das, Chishio Furukawa, Isabel Gunther, Ehsanul Haque, Mahabub Hossain, Katsuo Kogure, Christopher Ksoll, Kim Lehrer, Tomohiro Machikita, Tomoya Matsumoto, Jonathan Morduch, Kyle Murphy, Toshi Nakamura, Keijiro Otsuka, Adina Rom, Yasuyuki Sawada, Chikako Yamauchi, and participants at the CEA 2016 and JEA 2015 and seminars at ETH Zurich, GRIPS, and IDE-JETRO for their insightful comments and suggestions, as well as Nayamat Ullah Tasnim and Helal Uddin for their excellent research assistance. We are also grateful to the BRAC and Kopernik (and Daiwa Securities) for their generous contributions to our procurement of solar devices and Gana Unnayan Kendra (GUK) for providing great support for the study's implementation. Financial support from the IDE-JETRO for this research is also gratefully acknowledged. The authors have no relevant or material financial interests that relate to the research described in this article. The findings, interpretations, and conclusions expressed in this article are entirely those of the authors and do not represent the views of the IDE-JETRO. All errors are our own.

One of the core policies of most developing countries has been to improve the educational achievement of children. Traditionally, increasing school enrollment rates through supply-side interventions (e.g., in providing infrastructure, teaching support, and learning materials) has attracted widespread attention, and consequently most countries are on track to achieve universal access to primary education (Millennium Development Goal 2) (Pritchett and Banerji, 2013). As celebrated in United Nations (2015), indeed, the primary school net enrollment rate in the developing world has reached 91% in 2015. The number of children not attending primary school has also halved between 2000 and 2015. This praiseworthy accomplishment of school enrollment, however, has not necessarily resulted in improved learning outcomes, which has made the overall effectiveness of formal education questionable and caused many to rethink alternative educational interventions (Hanushek and Woessmann, 2011). Recent rigorous studies involving randomized control trials (RCTs) have provided valuable evidence regarding the effectiveness of various interventions on the quality of education and student learning, such as teachers' incentives (Duflo et al., 2012; Glewwe et al., 2010), remedial tutors (Banerjee et al., 2007), class size (Duflo et al., 2015), and computer-assisted learning (Beuermann et al., 2015; Mo et al., 2013); however, these studies still center around school inputs.

An important – but apparently neglected – aspect of previous studies is that students' learning depends on the after-school home-study environment, which is based on learning support (such as parental engagement or private tutoring for homework support) and learning-conducive inputs (such as adequate nighttime lighting for study). It is generally believed that after-school home-study enhances students' understanding of what they are taught at school (Copper et al., 2006; Dang, 2007; Dufur et al., 2013; Stinebrickner and Stinebrickner, 2008). As many students in developing countries are expected to work during the day to help their families, it seems critical that they should use the nighttime effectively for study.

Despite the importance of nighttime study, universal access to electricity has been inadequate and challenging for many low-income countries. As of 2013, the number of people in developing countries who live without access to electricity numbered 1.3 billion, of whom the majority resided in rural areas (IEA, 2013). Over 80% of these "energy poor" households, which lack access to reliable energy for lighting, generally depend on biomass- or fuel-based traditional lighting sources, including kerosene lamps, which are incapable of producing sufficient illumination. It is possible that students with insufficient nighttime lighting could systematically under-perform, as studying under unreliable and dim lighting conditions could make their learning less productive (Alstone et al., 2010). It could also be the case that these students have access to irregular and limited opportunities for nighttime study, as biomass fuels and kerosene are expensive, often comprising approximately 10% of the total household expenditure of the poor (see Bacon et al., 2010 and Maliti and Mnenwa, 2011). Furthermore, students who study under biomass lighting report poor visual performance, fatigue, and eye strain (Mills, 2014).

Portable solar lights have attracted increasing attention as an alternative, affordable lighting source in hard-to-reach areas (World Bank, 2010). It is expected that children who use them can gain additional study hours that could contribute to improving their academic performance (Esper et al., 2013). However, empirical studies aimed at systematically understanding the impact of solar lights are still scarce. This study intends to fill this knowledge gap by rigorously evaluating the impact of solar lanterns on a range of children's educational performance, such as time usage, school attendance, and educational achievement.

The areas under study are the river islands of Bangladesh, known locally as *Chars*. These river islands are prone to cyclical river erosion and floods, which frequently result in losses in terms of economic activities, possessions, and homes, thus disrupting families, livelihoods, and earnings. There is no provision of grid electricity in these river islands, and the Rural Electrification Board (REB) of Bangladesh has no plan to expand national grid-based electricity to *Chars* due to their susceptibility. Moreover, while part of the population have access to a large solar photovoltaic-panel-based electricity system, known as Solar Home Systems (SHSs), portable solar products were not available in the study location during the time of this research. These local settings are ideal for our study, less likely to suffer from attenuation of the true solar impacts due to contamination.

Exploiting this region's unique condition, we conducted an RCT in *Chars* located in northern Bangladesh, where we provided solar lanterns to a randomly selected subset of the population for 16 months (September 2013 to December 2014). Our target population comprised 4^{th} to 8^{th} grade students in primary and junior high schools whose academic performance was more likely to be affected by the possibility of nighttime study than that of elementary grade children. We selected 882 sample children and households for our study, and implemented the within-grade randomization at each school. To differentiate the treatment intensity, a proportion of the students received a bundle of a main high-capacity solar device along with two smaller lanterns, another proportion of the students received only one main high-capacity solar device, and the remainder acted as a control group and received no devices. The ratio of each group is approximately 5:4:9, respectively. In our experiment, no students that were offered solar products refused to take the offer.

While a handful of recent empirical studies have explored the socio-economic impacts of solar products, our experiment displays a striking strength for three reasons. First, our study is the first relatively large-scale randomization to evaluate the impact of better nighttime lighting on education. For example, previous studies have typically been based on small-scale pilots, and hence suffered from low statistical power due to their limited sample sizes: 155 in Uganda (Furukawa, 2012, 2014), 341 in Kenya (Hassan and Lucchino, 2016), and 300 in Rwanda (Grimm et al., 2016). Second, in contrast to the previous research conducted in areas that already had an influx of portable solar products in local markets, our study was situated in a location that was free from potential contamination by portable solar lighting or grid connection. In addition, the study site was also home to a substantial ultra-poor population that could be the main target of solar products. Third, in this study, we randomized the intensity of solar lighting by varying the product amount. Providing multiple solar lanterns reduces the likelihood that other family members exclusively utilize the products and therefore, discourage children's nighttime use for study.

As the empirical analysis will demonstrate, the treated children who received solar lanterns achieved no significant improvements in academic performance as measured by the school-based annual examination results, regardless of whether they received all three solar products or only one. To detect a possible channel that hindered the effectiveness of solar lanterns, we further explored whether the treated households actually used the solar lanterns, particularly for their children's nighttime study. We found that the treated students significantly increased their number of study hours, particularly at night and before exams and that they relied more on solar lanterns than on kerosene lamps. Furthermore, their school attendance initially increased for several months after the provision of the solar products; however, this effect disappeared over time. These increased education inputs (i.e., study hours and attendance rates), however, did not translate into improved educational achievements. Based on careful field observations and empirical findings provided by several exercises performed in this study, we provided evidence suggesting that the "no academic performance effects" are not attributable to the possible misuse of the products and spillover effects resulting from the within-grade randomization.

Consequently, an attempt to improve home-study facilities by providing solar lanterns alone did not result in (at least, short-term) positive impacts on children's educational achievement. Notably, this finding was obtained in our study setting, whereby students' marginal educational returns to solar products might have been the greatest due to their limited access to electricity at the time of intervention. This conclusion may suggest that unless other education-related inputs are also improved, it is difficult to systematically improve children's academic performance in the developing world through alleviating only one educational constraint. While we cannot entirely rule out other possibilities responsible for the absence of the positive academic performance effects, the limited effectiveness of education-related interventions that insufficiently consider complementarity across educational inputs has recently been widely observed in other settings (e.g., Glewwe et al. 2004; Glewwe et al. 2009; Mo et al. 2013).

This study is most closely related to Furukawa (2014) and Hassan and Lucchino (2016), wherein RCTs were conducted and the impact of solar lanterns on children's education was examined. Like us, Furukawa (2014) found an increase in study time, but no positive (or even negative) impacts on the test scores of children belonging to the 5^{th} and 7^{th} grades in Uganda. Furukawa (2014) suggested explanations for this finding: reporting bias resulting from the lack of any time-keeping device (e.g., a watch or clock) to measure study time at home; a decrease in study productivity because of a failure to fully re-charge solar products, causing the light to flicker; and intra-household conflicts about the ownership of solar products that might have prevented children from using the lamps to study. By providing treated households with a clock, a detailed pictorial manual to help them maintain their solar products, and a bundle of solar lanterns, our experiment was designed to reduce these potential problems while still yielding robust evidence to support the finding: "no academic performance effects."

By contrast, Hassan and Lucchino (2016) found positive treatment and spillover effects on the educational achievements of 7^{th} grade students in rural Kenya. The difference between their results and ours, especially in relation to spillover effects, may have arisen from the children's different study habits in two different experimental settings. Hassan and Lucchino (2016) highlighted the fact that, after dark, students shared lights at school; this sort of group learning was less likely to happen in our study setting, because it is quite risky for young children to go out at night in unelectrified river islands. Our follow-up survey confirmed that only three students in our study shared solar lamps with non-household members.

The remainder of the paper is structured as follows. Section I explains the study setting, sampling framework, and detailed design of the RCT. Section II discusses the summary statistics of the sample households. Section III outlines the estimation strategy, followed by the estimation results and the associated discussions in Section IV, Section V, and Section VI. Section VII concludes the paper.

I Survey and experimental design

This section explains our survey and experimental design.

Study setting

Our study area is the river islands located in northern Bangladesh, which were formed by sediments and silt deposits. These islands lie a mere few inches above the normal functioning river-water level. As monsoon precipitation coupled with excessive glacier melting of the Himalayas usually overflows the major river channels of Bangladesh, the river islands are extremely vulnerable to flooding during the rainy season. Most years during the flood, the residents of *Chars* are forced to evacuate to the mainland to seek shelter. The major mode of transportation from *Chars* to the mainland is via boats, which are poorly managed, unreliable, and susceptible to weather conditions. Therefore, living in *Chars* is highly precarious. The provision of electricity through the national grid is rare, and the REB of Bangladesh has hardly electrified any *Chars* due to infrastructure challenges associated with these types of geographical locations.

During our experiment in 2013, the only available sources of lighting, other than biomass- or fuel-based ones, were small-scale SHSs that were financed and operated by some NGOs in the northern *Chars*. However, the usages and marketing of such solar products were limited as SHSs are expensive for ultra-poor households residing in *Chars*.[1] Hence, coverage of business activities by these NGOs was minimal. As there exist hardly any alternative sources of electricity, most *Char* residents use kerosene-based lighting equipment, such as open-wick lamps and covered-wick lamps (known as "Hurricane" lanterns), as their main source of nighttime lighting, particularly for activities like studying and cooking. Some households used battery-powered flashlights for emergencies. However, these flashlights (also known as "Torch" lights) have very limited power to perform any additional tasks, and the required batteries are expensive and often unavailable to *Char* dwellers.

Solar devices

To study the impact of portable solar lanterns on education, we used d.light solar lanterns, which are certified and recognized under the World Bank Lighting Global Project (`https://www.lightingglobal.org/`). We collaborated with Gana Unnayan Kendra (GUK), a northern-based NGO in Bangladesh, in implementing our research project. In total, we had 500 units of the d.light S250, along with an additional 300 units of the other two types of product called the S10 and the S2, with the financial support provided by Kopernik, Daiwa Securities and BRAC. The details of these products are as follows (see also Figure S.1 in the supplemental appendix):

- S250: The d.light S250 is their flagship product, which provides bright light for a maximum of four hours and illuminates a room to the same degree as a 3 to 5-watt compact fluorescent lamp (CFL). This unit also has the functionality of charging cellular phones. The S250 has a separate lightweight solar panel that needs to be used to recharge the unit.

- S10: The d.light S10 is a portable solar light-emitting diode (LED) lamp that provides bright light for a maximum of four hours. This unit does not possess the functionality of charging mobile phones. The solar panel of the S10 is combined with the main unit.

- S2: The d.light S2 is the simplest and most highly efficient LED; it provides a focused light for a maximum of four hours. The illumination capacity of this unit is lower than that of the other two units. Like the S10, this unit also lacks the functionality of charging mobile phones. The solar panel of the S2 is also combined with the core unit.

In terms of lighting capacity, the S250 could provide, on average, 110 lumens of light (the lumen is the measure of light emission) based on the top brightness setting after a full day's solar charge; the S10 and S2, on the other hand,

[1] The minimum amount to be paid for a 10-watt panel with a 2.5 LED tube-light or a 5-watt CFL with a two-year installment package is 8100 taka (approximately 105 USD), which provides lighting for only four hours. See `http://www.gshakti.org/index.php?option=com\_content\&view=article\&id=115\&Itemid=124`.

could provide approximately 29 and 25 lumens of light, respectively. In comparison with traditional lighting devices used in Bangladesh, the kerosene-based open-wick lamp and the covered-wick lamp ("Hurricane" lantern) produce, on average, approximately 7.8 and 45 lumens of light, respectively (Mills and Jacobson, 2008).[2]

Sampling procedures

We selected children who were attending primary and secondary schools as our target population for this study. More precisely, as very few variations in schooling performance or study hours were expected at the elementary level, we focused on children who were enrolled in the 4^{th} to 5^{th} grades of primary school and 6^{th} to 8^{th} grades of junior high school.

To select children (and their households) to participate in this study, we began by listing all of the primary and secondary schools located in the *Chars* of the Gaibandha and Kurigram districts of northern Bangladesh; we then conducted quick initial inspections of the teachers and School Management Committees of these schools. To obtain internally valid estimates, without contamination effects, among all 28 schools in the eight *Chars* listed, we restricted our sample to 17 schools in two *Chars*, where SHS services provided limited coverage. Out of 1,665 total students belonging to the 4^{th} to 8^{th} grades in 17 schools, we initially selected 1,292 children as potential candidates for this study. The remaining 373 students were excluded, either because their homes (including school dormitories) had already been electrified, or because a sibling was one of the 1,292 students already chosen (i.e., for each household, we included only one child in our study sample). Potential participants were also excluded if their school attendance rate was lower than 80% over the previous four months. After drawing up an initial list of 1,292 students, we interviewed each child at his or her home to make sure that none of our participants had access to electricity or solar lights. Of these 1,292 children, we found 911 who had no access to electricity or solar lights at home during the period of our survey.[3] Of those, 882 became effective sample households for this study; the rest of the children in the sample had dropped out of school to get married or for other practical reasons (e.g., land erosion, resulting in forced migration) before the detailed baseline household survey was conducted. Figure S.2 in the supplemental appendix illustrates the detailed timeline for our surveys and interventions, along with Table S.1, which reports on the number of students selected through the screening process described above.

During the baseline survey conducted in July and August of 2013, we collected detailed data at the household level to understand the socio-economic conditions of the sample children and their households. The data included household demographic characteristics, details of energy use and its sources, expenditure, various income generating

[2] This does not necessarily mean that the traditional Hurricane lantern provides more brightness than the S2 and S10, because the former cannot maintain effective brightness/lumen for long hours due to the emission of carbon smoke.

[3] It emerged that the remaining students had access to SHS services, through the support of NGOs.

activities, durable and nondurable assets, and debts and savings.

Experiment and survey

Once we had completed the baseline household survey, we organized a public lottery to randomly allocate to the eligible students access to the use of solar lights in two different bundles of products for 16 months (September 2013 to December 2014). The first treatment bundle (Treatment A) contained all the d.light solar products, i.e., the S250 (solar lantern with mobile recharging), the S10 (general solar lantern with no cellular recharging facility), and the S2 (simple solar lantern), altogether providing approximately 164 lumens of lighting capacity at top brightness settings. The second treatment bundle (Treatment B) contained only the S250 solar lantern, providing lighting capacity of 110 lumens at the maximum brightness setting. By differentiating the treatment intensity, we are able to explore whether the provision of smaller lanterns had any additional impacts, such as facilitating and ensuring intended use of the main product by the targeted children. For example, other members of the treated households may have wanted the solar lanterns for their own use (for example, to facilitate cooking), which may have reduced the impact of the solar lanterns on the targeted students. Hence, bundling additional solar products may have reduced the probability of such alternative unintended usage by other household members and siblings.

We held public lotteries, at each sample school, in the presence of parents, teachers, and village elites. Students and their parents drew a lottery by themselves and were classified into one of the following three groups accordingly: (1) Treatment A, (2) Treatment B, and (3) the control group that did not receive any solar lantern. The randomization was separately implemented at each school for each grade, so that the ratio of Treatment A, Treatment B, and the control groups was maintained at approximately 5:4:9 for each grade at each school. By allowing each household to join the lottery only once, we avoided the possibility that siblings from the same household would be simultaneously in the treatment and control groups. After the public lottery, there were 248 students in Treatment A, 198 students in Treatment B, and 436 students in the control group (see also Table S.1 in the supplemental appendix). In our experiment, no treated students refused to use the offered solar products.

To effectively recharge the solar products, obstructions to sunlight (e.g., walls, trees) needed to be avoided. Furthermore, the tilt angle of the panel was also important for adequately recharging the lanterns under sunlight. To facilitate proper maintenance and the correct recharging practice, a product manager of a local selling agency was invited to the study site to train our enumerators, who in turn instructed the survey respondents and their children. Moreover, to ensure that these sets of instructions were readily available to our sample households, we provided each of them with a detailed pictorial manual. This manual contained elaborate information on the adequate use/maintenance and recharge techniques of the solar lanterns. It also included a detailed time diary for maintaining hourly records of each student's time use for various activities (e.g., hours of playtime outside of school, study time at home, etc.) (see Figure S.3 in the supplemental appendix for a sample of the collected time diary). Teachers were held responsible for regularly checking these time diaries, which were periodically collected by our survey team. Furthermore, to facilitate accurate time keeping, we gave both the treatment and control students a wall clock and set of batteries.

After the implementation of the randomized control trial, we periodically visited the schools to collect the monthly time-use diaries. Moreover, one year after the baseline survey, we implemented a follow-up study of the same children and their households to construct a picture of any welfare and behavioral changes that had taken place over one year. During the follow-up phase, we could trace 852 of these households (i.e., 96% of the 882 original sample households), thus with the minimal rate of sample attrition; the rest had been lost due to attrition for reasons such as relocation or marriage. Furthermore, we collected the detailed annual examination scores of each student from our sample schools for both the 2013 and 2014 academic years.

To comply with ethical concerns, access to solar lights was provided for 16 months and was subject to withdrawal and re-distribution to our control households following the research. To ensure that this process went smoothly, we issued legal documentation to each treated household, describing the conditions for access to the solar lights, including information on proper use, product responsibility, prohibitive practices (e.g., renting or sub-leasing), and withdrawal requirements.[4] In this contract, we made the households responsible for product loss (e.g., theft), which might have encouraged no such cases occurring in our experiment in the end. However, in the case of product malfunctioning (e.g., defects), we replaced the product on verification of the malfunction by the sales unit. We believe that this process reduced the possibility of contaminated data from the product's unintended use.

Note that the way a new technology is obtained (whether through free distribution or purchased from a market) may affect its use and resulting socio-economic impacts (Ashraf et al., 2010; Cohen and Dupas, 2010). Therefore, the findings of the current research project are limited by its experimental design and should be viewed with caution when considering the influence of provided solar lamps in general.[5][6]

[4] Relatedly, we began this research by approaching school headmasters and School Management Committees to explain the project details and obtain their verbal approval. Next, we visited households to confirm their eligibility and explain the survey and study design; before starting our baseline survey, we obtained their written (signed) consent. We went through the same steps to obtain the participants' consent before conducting a follow-up survey. Information on the students' academic performance was collected directly from the schools, once all of the parents and School Management Committees had approved this form of data collection. Our survey questionnaire adopted the standard income and expenditure modules used in the Bangladesh Bureau of Statistics (BBS) Household Income and Expenditure Survey.

[5] In this study, the solar lanterns were given for free to use for 16 months (cost-free leasing); people who pay to lease such lanterns may be influenced by the sunk cost effect to use them more intensively. However, Ashraf et al. (2010) and Cohen and Dupas (2010) provided no evidence to support such effects in the context of health-related products. In addition, charging non-zero prices for solar lamps or any other items may encourage those most committed to using the products to purchase them, while reducing the wastage that results from unused products. While the available evidence is mixed (e.g., Ashraf et al., 2010; Cohen and Dupas, 2010), Ashraf et al. (2010) makes the point that large up-front costs and the product's ability to be extensively used for secondary purposes may facilitate such screening effects. While the market price of solar products may not be particularly high for most households, ultra-poor households may not be able to afford them. Given that solar lanterns can also function as cellular phone chargers, this modern technology might have been more intensively used (due to screening effects) if we had leased the lanterns at non-zero prices.

[6] A one-time free distribution of solar products may also affect users' subsequent purchasing/adoption behavior by altering their reference points (i.e., anchoring effects) and/or the perceived product benefits (i.e., learning effects) (e.g., Dupas, 2014). Relatedly, a limited time lease may also encourage users to treat the technology carefully.

II Data

Table S.2 in the supplemental appendix provides a description of the key baseline variables of the survey students (Panel A) and their households (Panel B) by treatment arms. To ensure that the randomization worked well, Table S.3 reports the regression coefficients of these variables on the treatment arms, where the control arm was used as a reference group. While only a few variables indicate statistically significant differences across the treatment arms, most variables are reasonably well balanced. Hence, we can reasonably ascertain that the randomization conducted in this study using public lottery was successful overall.[7]

As Table 1 indicates, kerosene-based products (supplemented by flashlights) were the major lighting sources used in our survey area during the baseline phase. By survey design, no one had access to solar lights during the baseline survey. Almost all the households owned at least one kerosene lamp or lantern ("Hurricane"), of which approximately 24% were equipped with a kerosene lantern, which was generally more expensive than the lamps (Panel A of Table 1). On average, the sample households used approximately 4.8 and 6.2 hours per day of kerosene-based lighting sources in the rainy and off-rainy seasons, respectively (Panel B of Table 1). Annual expenses on kerosene corresponded to approximately 2% of total household expenditure, which was also equivalent to approximately 15% of total household non-food expenditure (exclusive of school fees, medical fees, and expenditure on other energy sources). This suggests the significance of fuel costs in the total budget of our target population (Panel C of Table 1).

Panel D of Table 1 presents the major activities when using each of the lighting sources. The figures reflect the proportion of respondents who used each light source as a major source for corresponding activities (reported through multiple answers). For instance, approximately 98% of households that owned kerosene lamps used them for both reading/studying and cooking/eating at night as major activities, followed by 68% for walking outside at night. Similarly, those who owned kerosene lanterns primarily used them for reading/studying activities. It is clear that flashlights played only a supplemental role in lighting (i.e., for studying, walking at night, or social interaction).

III Empirical strategy

To identify the causal impacts of the solar lights, we estimated the following reduced-form empirical model of an education production function (Hanushek, 1979) by ordinary least squares (OLS):

$$y_{ij} = \alpha_1 + \alpha_2 d_1 + \alpha_3 d_2 + \alpha_4 \mathbf{x_{ij}} + \epsilon_{ij}, \tag{1}$$

[7]By exploiting separate (sub-)samples of the data, we also regressed the treatment status on these variables in Table S.4 in the supplemental appendix, whereby it was confirmed from column (d) that all coefficients explaining the treatment status were jointly insignificantly different from zero.

where y_{ij} is the outcome of interest in the follow-up survey for a student i (or a household i for some outcomes) living in a village j; d_1 (d_2) is an indicator for the treated households that received Treatment A (Treatment B); the vector $\mathbf{x_{ij}}$ contains several baseline characteristics of the respondents (including school- and village-fixed effects); and ϵ_{ij} represents a stochastic error term. Outcome differences that can be attributed to school inputs are controlled for by the inclusion of school-fixed effects. The $\mathbf{x_{ij}}$ includes the variables reported in Table S.2 in the supplemental appendix, namely students' age (years), gender (dummy), and completed education (years) (which is almost equivalent to the child's grade); household size; the number of males in a household; age of household heads (years), gender (dummy); completed education (years); and land size.

Given the preceding observation that most individual or family characteristics are well balanced across the treatment arms, our randomization successfully makes the variables d_1 and d_2 orthogonal to ε_{ij}, thereby freeing the associated estimates from any endogeneity bias. In addition to checking the statistical significance of the treatment effects of α_2 and α_3, the equality of these two coefficients as well as the significance of the total effects of the two treatment arms was also tested and the p-values of these tests are reported in the tables presented in this paper. Furthermore, the mean value of the outcomes that correspond to the control group is also demonstrated at the bottom of these reported tables.

Throughout the paper, the standard errors are robust to heteroskedasticity and adjusted for clustering in grades within the same school (39 groups) for educational outcomes or in villages (42 groups) for other outcomes relevant to households. The clustered standard errors at the school-grade level would be appropriate in the present context, because unobserved error terms are less likely to be correlated across grades within the same school. Compared to clustering at the school level (17 groups), it would also increase the reliability of the statistical inference while avoiding a problem arising from exploiting few clusters (Cameron and Miller, 2015).[8]

IV Educational achievement

First, we analyzed the impacts of solar products on children's educational achievement, reported in Table 2. The dependent variable in Table 2 took the value of one if the students passed the exam in the corresponding year. This educational achievement indicator was measured by the results of the schools' annual final examinations held in December of 2013 and 2014. Columns (a)—(c) of Table 2 report the impact of solar lanterns based on the 2013 results, whereas the estimations reported in columns (d)—(f) are based on the 2014 results. Without controlling for other covariates, columns (a) and (d) of Table 2 report whether the treated students progressed more successfully to

[8] However, clustering standard errors at the school level barely affected the implications obtained from this research.

the next grade compared with the control students in 2013 and 2014, respectively.[9] Columns (b) and (e) reported the impact of solar lanterns on academic achievement for 2013 and 2014, after controlling for individual and household-level observables. Instead of the linear probability model (LPM) reported in these columns, probit estimations and their corresponding marginal effects (MEs) are reported in columns (c) and (f). The mean grade progression rates of the control students, who did not receive solar products, were approximately 72 and 64 percentage points in 2013 and 2014, respectively. As is shown by the insignificant coefficients, the solar products had no statistically significant impact on the treated students' academic progression compared with the control students, regardless of whether the students received all or only one of the products.[10]

Table 3 also reports the impacts of solar lanterns on the test scores, separately for each year and each subject, i.e., Bengali, English, math, general science, Islamic studies, and Bangladesh general studies. For brevity, we suppressed the coefficients of the baseline controls when reporting the estimation results. Courses and subjects of these annual examinations varied somewhat across schools and grades. Although such school-level heterogeneity can be mitigated to some extent by school-fixed effects, the analysis presented here focused on core subjects and estimated the z-scores of the GPA (ranging from zero to five), which was constructed based on methods prescribed by the Bangladesh Ministry of Education.[11] The regression outputs in columns (1a)—(1l) are based on the academic performance in the final examination held in 2013 and those in columns (2a)—(2l) are for 2014. For each core subject, we reported two regressions, with and without baseline controls. Based on the estimations reported in Table 3, we again found no statistically discernable impact of solar lanterns on the academic performance of our treated students. The impacts were insignificantly different from zero, and negative if there was any significance.

In Table S.5 in the supplemental appendix, we also performed an additional analysis of interacting the treatment indicators with the baseline controls $\mathbf{x_{ij}}$ and estimating their impacts on the children's progression to the next grade in the 2013 and 2014 examinations (although the baseline controls could not necessarily be seen as exogenous in affecting academic performance).[12] The analysis reports no distinct heterogeneity of the treatment effects while, again, providing no support for an improvement of academic performance induced by solar products. The corresponding estimation results on GPA scores were reported in Table S.6 to Table S.11 in the supplemental appendix.

[9] Based on the academic rules in Bangladesh, students can progress to the next grade if they take the examinations of all the necessary subjects and achieve GPA scores equal to or greater than one in all subjects.

[10] Given the estimated treatment effects and the associated standard errors, we would also be able to reject the null that students' progression rate increased by 5—10% at the conventional significance level.

[11] For some schools, the language examination (Bengali and English) comprised two parts. For the sake of comparison, in such cases, we calculated the GPA as the average GPA between the two parts of the same language examination. Furthermore, for students who failed to take the examination in one or more subjects, the GPA score for those subjects was assumed to take the value of zero. Moreover, in 2014, one school did not hold an annual examination for one of the core subjects (i.e., Bangladesh general studies) for students enrolled in grade five (24 observations). In the analysis, it was also assumed that these students received a GPA value of zero in this subject.

[12] Together with the level effects of the treatment indicators, the coefficients on those interaction terms are presented in Table S.5. Note that the reported level effects are not directly comparable with those demonstrated in Table 2 because those in Table S.5 are evaluated at the point of the $\mathbf{x_{ij}}$ taking the value of zero.

V Why no improvement?

Apart from possible spillover effects as will be carefully discussed in Section VI, three possibilities may explain the findings of the "no academic performance effects" of solar products. First, it is possible that the treated households did not use solar lanterns due to the products' malfunctioning. Second, it may be the case that the treated households used the products for purposes other than education. Third, it is possible that learning under solar lighting is not systematically more productive compared with the alternatives. The treated households might have used the solar products for nighttime study, which ensured an essential input for the education production function; however, bright lighting alone may not be sufficient to improve children's learning and school performance. In what follows, we examine each possibility in detail to identify why we did not observe significant impacts of modern lighting technology on educational achievement.

Usage of solar lanterns

The estimation results depicted in Table 4 enable us to reject the first possibility. In columns (a)—(l), reported in the first two panels of Table 4, we analyzed the average hours of use (per day) of different lighting products by the treated households compared with the control households, separately for the rainy and off-rainy seasons and each lighting source.[13] As before, for each dependent variable, we reported the regression estimates with and without the baseline controls. As the results indicate, the provision of solar products significantly reduced the use of kerosene products. This was particularly so for households that received all three solar products. While statistical significance and magnitudes were somewhat weaker compared with the case of kerosene products, similar implications can also be obtained for flashlights, implying that treated households efficiently substituted kerosene products with solar lanterns.

Columns (m)—(r) of the final panel in Table 4 show the impact of solar lanterns on the logarithmic value of household expenditures. As can be clearly observed from the results in columns (o) and (p), households that received three (one) solar products reduced their kerosene expenditure by approximately 75% (50%) over the last 12 months of 2013—2014, as compared with the control households. As explained in subsection S.3.1 in the supplemental appendix, during the follow-up survey, many treated households that reported zero expenditure on kerosene (presumably due to the substitution of solar lamps for kerosene products) were dropped from the estimations. We assume that the treatment group reporting on kerosene expenditure during the follow-up included a greater proportion of households more likely to use kerosene products than the corresponding control group. If this was the case, then the true treatment impact on kerosene expenditure may be even more negative. Consequently, this significant reduction in

[13] Unlike students' time-use that is analyzed in Table 5 based on a time-diary information, these average hours resulted from information collected in a follow-up household survey.

kerosene expenditure contributed to a decline in the total expenditure of treated households by 2 to 6% (reported in columns (q) and (r), respectively). This decrease in annual expenditure corresponds to approximately 21—63 USD. The products cost 39.6, 13.6, and 9.7 USD (based on the exchange rate at the end of October 2016) for S250, S10, and S2, respectively. Given product durability (at least five years with normal use) and the potential health benefits resulting from indoor air-quality improvement, solar lamps appear to be cost-effective and to increase household savings. These findings make us reasonably confident that treated households genuinely used the solar products.[14]

Educational inputs

Given the rejection of the first possibility that might explain no positive treatment effects on educational achievement, this subsection checks the second possibility by investigating the impacts of solar products on students' educational inputs in Table 5 and Table 6.

In Table 5, we first estimated the impact of solar products on students' use of time, with or without baseline controls. Data on the daily time-use activities of our sample students were periodically collected from September 2013, using time diaries that our research team had asked each household to use to record their daily time-use activities. Using information drawn from these diaries increased the reliability of our analysis. However, a significant amount of time-use information was unavailable after April 2014, because of several happenings, including a change in the diary format and the training of those carrying out the survey (May and June), a school holiday for Ramadan (July), and floods that caused the temporary evacuation of (some) respondents to shelters (August). This natural disaster also made it difficult for teachers to ensure that students regularly filled out their time diaries, once school resumed in September. For these reasons, we could only use the time diary information gathered between September 2013 and April 2014; the relevant estimation results during this period are detailed in Table 5.

As the results in Table 5 show, our estimates reveal that, on average during the eight-month period, treated students significantly reallocated the amount of time used for home study, reducing daytime study by approximately 5—8 minutes each day, and increasing nighttime study by 20—25 minutes. The net effect of solar lanterns on study time at home was found to be statistically significant and positive. This net effect can be translated into an increase of 45—75 hours of home study time over eight months. In addition, comparing the treatment effects in columns (e) and (k) in Table 5 with the control mean reported at the bottom of these columns and columns (d) and (j), treated

[14] In Table S.12 in the supplemental appendix, we also attempted to assess treatment effects on a household's willingness to buy solar products. The dependent variable takes one if the respondent is willing to buy each type of solar lantern. This variable measures subjective satisfaction; the corresponding information was collected during a follow-up survey. As the results in columns (a) and (e) show, treated households became more willing to buy solar lamps than those in the control group. We also estimated the willingness of both treatment and control group households, which showed an interest in purchasing solar products, to buy particular products in columns (b)—(d) and (f)—(i). Interestingly, treated households were mainly willing to purchase products they had used during the experiment. In other words, households that had received only one product (S250) generally wanted to purchase S250, whereas three-product users were willing to buy all three products. The increased satisfaction revealed by these exercises also confirms that the treated households genuinely used the solar products.

students substituted solar lamps for kerosene lamps almost completely, in order to study at night. Moreover, there was no significant difference in the treatment effects on children who received three solar products and those who received only one solar lantern.[15] Learning is a process of accumulating knowledge. Compared with kerosene-based products (that rely on expensive fuels), solar lanterns also provide reliable lighting conditions that supposedly make learning more productive. Considering these possibilities, the identified increase in home study time must not be undervalued.

Figure 1 plots the estimated monthly treatment effects (with 95% confidence intervals) on daily time use during the eight months. Home-study time increased by approximately 20 hours in November, just before the annual examination season (December) in Bangladesh. On the other hand, the time spent on other activities (sports, cooking and bathing, household chores, sleeping and rest, and other activities) declined during that month. This increase in home-study time in November is not negligible, given that the control students spent approximately 120 hours, as a mean, studying at home that month; students intensively prepare for an examination in November in order to move up to the next grade.

One may challenge the accuracy of the students' self-reported time use, given the potential for measurement errors. However, the distinct time-variation associated with the treatment effects helps to alleviate this concern.[16] If the self-reported study hours were entirely noise, it then becomes difficult to explain why they increased just before the examination season. While the respondents may have over-reported their nighttime study hours, for reasons of social desirability bias, there is no a priori reason why such a response bias should have led to a reduction in the number of daytime study hours reported, as seen in columns (c) and (i) in Table 5. Moreover, potential measurement errors in the dependent variables would have affected the efficiency of the estimates, and not (as long as they were classical) their consistency.[17]

The research team made surprise visits to catchment schools in February, April, and August 2014, and checked on the children's school attendance. The estimated impacts are reported in columns (a)—(d) (with no baseline controls) and (e)—(h) (with controls) in Table 6. As the results indicate, treated students who received three solar lamps (Treatment A, all products) attended school more regularly, as revealed during our first two visits in February and April. However, this positive impact did not last long; it became statistically insignificant in August 2014. In columns

[15] In Table S.13 in the supplemental appendix, we have disaggregated the treatment effects on student time spent on "other activities" (estimated in columns (f) and (l) in Table 5) into "sports," "cooking and bathing," "household chores," and "other activities, including sleeping and rest." We obtained some (albeit statistically insignificant) evidence that suggests treated students reduced the time they spent on "other activities, including sleeping and rest."

[16] Instead of using a time diary, we could have employed a more sophisticated sensor to measure the students' time use. However, such a device would not necessarily have been more accurate than the time diary in measuring the number of hours the students used to study. There would still have been a concern about the accuracy of measurements unless the research team had been able to monitor the students' use of the sensor; that would have required precise (and practically impossible) monitoring of the students' behavior during the experiment.

[17] By treatment arms, Table S.14 in the supplemental appendix provides similar information to that reported in Table 1, collected during a follow-up household survey. As seen in Panel D of Table S.14 (presenting the proportion of respondents who used each light source to enable activities through multiple answers), approximately 73% (100%) of households that received three (one) solar products used S250 for reading and studying. Interestingly, compared to households that received three products, households that received only S250 used this flagship lamp more intensively for reading and studying.

(d) and (h), we consolidated the three visits into a single estimation, along with the visiting months, as a control. The results suggest that, overall, the probability that a treated student - receiving Treatment A - would be found attending school during a surprise visit was approximately 8 percentage points higher than the probability for control students, whose mean attendance was approximately 54% during the investigation periods. This estimate is comparable to that provided by Miguel and Kremer (2004) in their de-worming study in Kenya; compared to our study, however, it may have been harder for the de-worming program to achieve an estimate of a similar magnitude, as the initial attendance rate was already higher there than in our area of study.

To further assess the estimates, we carried out a cost-effectiveness analysis, following the method used by Dhaliwal et al. (2013) and Evans and Popova (2016) (see Section S.1 in the supplemental appendix for the details). To simplify the analysis, we considered only the cost (prices) of the solar lanterns, ignoring other factors such as research administration costs, reduced kerosene expenditure, and product maintenance opportunity costs. Assuming that the life of a solar lantern is five years, the minimum length of time for which products function effectively in normal conditions, our intervention raised student participation by 0.59—64 years per 100 USD spent. Referring to Evans and Popova (2016) (Table 3 in p. 268), this increase can be compared with that revealed in Evans et al. (2008)'s study, which involved distributing school uniforms in Kenya.[18]

Educational efficiency

Thus far, this study has demonstrated that while providing solar products increased children's educational inputs (i.e., hours studied, school-attendance record found on a surprise visit), it did not result in an improvement in their educational achievement (subject test scores and overall GPA). Thus, we are left with the third possibility that learning under solar lighting is not as substantially productive and solar lighting alone is not sufficient to improve children's learning and schooling performance.

To verify this possibility, in column (a) of Table 7, we exploited the study hours and school attendance (estimated in the analysis of Table 5 and Table 6) as regressors to explain the likelihood of children progressing to the next grade after taking the 2014 examination (see Table S.17 to Table S.19 in the supplemental appendix for the corresponding estimation results on GPA scores). The dependent variable is the same as in Table 2, columns (d)—(f). Surprisingly, the educational inputs - home-study hours and attendance record - have no significant association with children's progression to the next grade. Furthermore, including the treatment dummies in Table 7, column (b) shows virtually no influence on the estimated relationship between the educational inputs and achievement. Given the significant

[18]To check the treatment heterogeneity on educational inputs, in Table S.16 in the supplemental appendix, we also performed similar exercises to those in Table S.5 for the total study hours from September 2013 to April 2014 and indicators of children's attendance at our school visits in February, April, and August in 2014. Overall, no noticeable heterogeneity was found.

treatment effects on the educational inputs presented in Table 5 and Table 6, this result also confirms no correlation between the inputs and school performance.[19]

One explanation for the absence of a statistically significant relationship between the educational inputs and performance is that the effectiveness of the educational inputs might have been heterogeneous across the treatment groups. For example, as having solar products made nighttime study more feasible, the treated students might have substituted daytime study with nighttime study, and, consequently, spent more hours on non-study related activities (e.g., family business, income-generating activities, or sports). Then, it is certainly possible that these students were too tired due to their non-study-related activities, which hampered effective study at night, which in turn made their academic performance no different from that of the children who did not receive solar products.

As found in columns (c) and (i) of Table 5, the daytime study hours for the treated children did, in fact, decrease due to the use of solar products, thus indicating substitution effects. To check whether the efficiency of the educational inputs varied across treatment arms, in column (c) of Table 7, all the input measures interacted with the treatment dummies. The results revealed the heterogeneous impact of the measured inputs. For instance, within the group of treated students who received all three solar products, those who spent more time on daytime study were more likely to progress to the next grade. Furthermore, a positive influence of school attendance in August was found in the examination results for the treated students who received one solar product.

Admittedly, a strict causal interpretation of these findings must be discouraged due to the endogeneity of the input measures.[20] For example, the treated students who studied hard during the daytime - despite their access to solar lamps - or who attended school more frequently, might have had some unobserved family advantages in regard to their schooling or diligent personalities. Nevertheless, these findings still suggest that despite the consideration of the heterogeneous influence of the educational inputs, their statistical link with students' educational achievement remains marginal in general.

A growing body of empirical research has suggested that relaxing only one educational constraint may not result in children's improved school outcomes in the developing world (e.g., Glewwe et al. 2004; Glewwe et al. 2009; Mo et al. 2013). Given that solar lamps were also expected to address only one factor that encouraged children's human capital acquisition, i.e., better nighttime lighting for home study, our findings are consistent with those provided by recent studies. Relatedly, complementarity across educational inputs (e.g., textbooks, teacher quality, and home-study support) may play an important role in determining academic performance. Accordingly, our findings may imply that

[19] Note that if students study hard due to unobserved personal aptitudes or learning-supportive family attributes, the estimated relationship between educational inputs and achievement can be seen as causal effects biased upwards. In such a case, the estimation results in Table 7 suggest that a great educational input might even have reduced the students' academic performance in our area of study.

[20] Theoretically, it is possible to estimate an education production function by exploiting the treatment indicators as instrumental variables for the measures of educational inputs. However, this exercise was not undertaken in this paper, because the statistical significance of the treatment effects on the educational inputs was not strong enough to enable this study to do so.

the solar lanterns had a limited impact on children's academic performance, while other education-related inputs remained constant. In Section S.2 in the supplemental appendix, we discussed this possibility more carefully.

VI Spillover effects

The potential for spillover effects is a threat to the previous findings.[21] In other words, as the randomization was carried out within a specific grade level at each sample school, it is certainly possible that a student who did not receive solar products could have benefited from her friends who did receive the products, or from having access to SHSs for nighttime study. However, visiting a friend's home at night in *unelectrified river islands* is quite risky, for both boys and girls. In fact, in a follow-up household survey, we collected information on whether treated students shared solar lamps with non-household members, and identified only three such cases, where solar lamps were shared with cousins. Hence, this possibility may not have been a valid concern in our setting.

Other spillover effects could have resulted from interactions in school and during exams. Non-treated students could have learned from their treated peers in school, minimizing the difference in outcomes between the treatment and control groups. However, if such spillover effects artificially blurred the academic performance gap between the treatment and control groups, they also may have made it difficult to detect significant differences in educational inputs among students. Finding significant increases in study time and school attendance among treated students could reduce this concern. However, it is still important to consider this possibility more carefully.[22]

Two exercises were conducted. First, we collected information on the average progression rates in one of the studied districts, Kurigram, in 2012, 2013, and 2014; these were 0.93, 0.98, and 0.97 for primary-school students and 0.83, 0.89, and 0.86 for secondary-school students, respectively (i.e., a marginal increase in the progression rate from 2012 to 2014). In our control group, the progression rates in 2012, 2013, and 2014 were 0.80, 0.78, and 0.70 for 4^{th} to 5^{th} grade students and 0.67, 0.64, and 0.58 for 6^{th} to 8^{th} grade students, respectively (i.e., a decline in the progression rate from 2012 to 2014). Thus, we have no evidence to suggest that, on average, the academic performance of our control students improved in a more pronounced way during the sample periods than did the performance of all the Kurigram students.

Second, we exploited the insight obtained from Baird et al. (2014) that the fraction of those offered treatment in

[21] Further threats also exist. First, while the number of households lost in the follow-up survey – due to attrition – was small, the sample selection associated with the missing outcome data remains an empirical concern. Second, continuous rainfall struck northern Bangladesh in August 2014 and this weather shock might have made the subsequent learning of all the sample students indiscriminate. Third, in this study exploring the impacts of two treatment arms on multiple outcomes, we may accidentally have found statistically significant treatment effects for some arms and outcomes, even where true causal effects were absent. These concerns are carefully addressed in Section S.3 in the supplemental appendix.

[22] On the other hand, it is also possible that the control students were disappointed at losing the lottery, and therefore did not study as hard during the sample periods. This possible discouraging effect (if any) would have led us to overestimate the treatment effects on children's educational achievement. If so, the true performance impact of solar products would be smaller than current estimates, while further supporting the result of "no academic performance effects" found with modern lighting technology.

a cluster (i.e., treatment saturation) could be used to estimate the spillover effects on the non-treated population. Recall from Section I that each grade at each school potentially consisted of four types of students: (whether treated or not) our study sample, their siblings (note that in each household, only one child was included in our study sample), those with access to electricity at the baseline, and those with poor attendance. This experimental design enabled us to explore whether the fraction of treated students and their siblings in each school grade (i.e., treatment intensity) influenced the students' educational achievement, after controlling for the school grade fraction of regularly attending students with no access to electricity at the baseline (i.e., eligible fraction), whereby both fractions varied across grades within a school. Note that the latter fraction was endogenous. However, given this control, the former fraction was expected to have random variation. This approach is similar to that adopted by Miguel and Kremer (2004) and Oster and Thornton (2012). Having no statistically significant relationship between treatment intensity and educational achievement reduces any concern about spillover effects.

As detailed in subsection S.3.2 in the supplemental appendix, the relevant estimation results provided no strong evidence to suggest that the "no academic performance effects" of solar lamps should be attributed to a positive learning externality. Note that the absence of spillover effects is consistent with both views - that learning interaction between the treated and remaining students existed or did not exist. Given the absence of significant treatment effects, the former case may suggest that solar lamps did not provide treated students with any educational benefits (in terms of performance) that could have been transferred from them to the remaining students.

VII Conclusion

There is a growing public interest in the diffusion of affordable modern off-grid solar lighting to help students in less-developed countries with their learning. While anecdotal evidence that emphasizes the potential of such modern technology is accumulating, rigorous empirical evidence remains scant. This study aimed to provide one of the few rigorous evaluations of the short-term effects of solar products on education in less advanced economies. To meet this research objective, we conducted a randomized field experiment in the river islands ($Chars$) in northern Bangladesh that had no access to an electrical grid, where a proportion of the randomly selected students received three solar products, another proportion of the students received one main solar product, and the rest were kept as a control group and received no solar products.

Our study found that households that received solar lamps substituted this modern technology for traditional light sources, such as kerosene lamps/lanterns. This behavioral change resulted in a significant decrease in annual kerosene expenditures, which in turn reduced the total household expenditures. Solar products also increased the net study hours at home for our treated children by increasing their nighttime study hours and reducing their daytime study hours. This increase in the net number of study hours was more evident before the examination season, while the time spent on other activities during that period was reduced (e.g., household chores). Furthermore, we found that the school attendance rate initially increased due to the provision of solar lanterns, but declined over time. However, despite these increases in study hours and school attendance, there was no evidence to support the notion that children who received solar lamps achieved higher examination scores than those who did not receive these supports. These results hold true irrespective of whether students received all three solar products or only one. To assess the internal validity of our findings, we also considered several threats to the findings (e.g., sample attrition, learning externality, multiple-hypothesis testing). The exercises performed to address these issues provided additional evidence rejecting that the above findings were entirely attributed to erroneous statistical inference (see Section S.3 in the supplemental appendix for the details). Notably, no improvement of academic performance is less likely to stem from the potential spillover effects.

On one hand, our experiment was conducted in a setting where students' marginal educational returns to solar products were expected to be the greatest for several reasons. First, access to electricity was highly limited in the studied areas. Second, we distributed solar lanterns directly to students at schools, which might have given them priority to use the products over other household members, compared to a case in which the products were provided for household heads. Furthermore, replacing kerosene lamps with solar products could potentially improve students' health, such as their respiratory systems, which may, in turn, positively affect academic performance. In this sense, finding no improvement in academic performance in our experiment may imply that we cannot expect to see educational achievement effects from introducing solar products in other modestly disadvantaged settings.

In contrast, the site studied in this research also had many other educational constraints, such as the availability of good teachers and households' ability to afford education. Thus, it is also possible that providing solar products for students with better educational environments than those in our study area would result in improved educational outcomes. Whether this is true may depend on the overall quality of educational inputs and complementarity across them, such as access to light, home learning environment, school facilities, and teacher quality. In fact, an experiment in such improved settings may prove to boost the educational achievement of all the relevant students. Furthermore, health improvements may progress very gradually, or there may be a critical age range in terms of solar products and the noticeable improvement in children's health. If that is the case, we may observe the positive impacts of solar lanterns on health only in the long run or for some particular age cohorts, and thus any synergetic effects between health and education should also be realized only in the long run or for those cohorts. To generalize our findings in a much broader context and provide conclusive evidence on the educational effectiveness of solar products, further empirical research is required.

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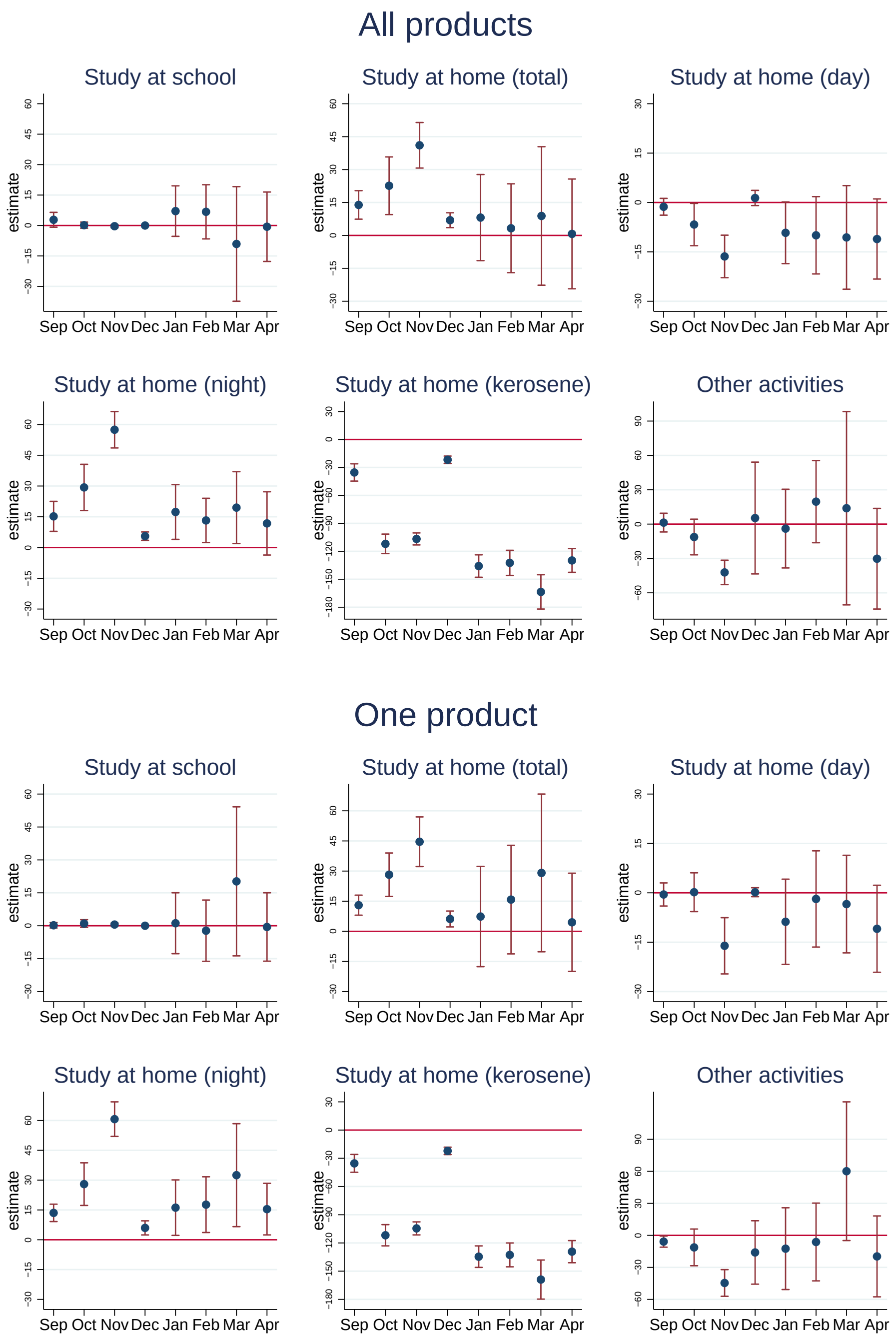

Figure 1: Impacts on children's time use (per-day minutes)

Notes: (1) This figure reports α_2 and α_3 in equation (1) with 95% confidence intervals. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) Other activities include sports, cooking and bathing, household chores, and some other activities, including sleeping and rest.

Table 1: Information on lighting sources at baseline

Panel A: No. of light sources (882 households)

	Mean	Std.
Flashlight	0.11	0.33
Kerosene lantern	0.24	0.46
Kerosene lamp	1.67	0.58

Panel B: Per-day usages of lighting sources (882 households)

	Mean	Std.
Flashlight (rainy season)	0.29	0.88
Flashlight (off-rainy season)	0.41	1.24
Kerosene lanterns (rainy season)	0.62	1.28
Kerosene lanterns (off-rainy season)	0.78	1.60
Kerosene lamps (rainy season)	4.13	1.78
Kerosene lamps (off-rainy season)	5.39	2.41

Panel C: Expenditures (in Bangladesh Taka, BDT)

	Mean	Std.
Food (12 months)	59841.14	26061.42
Education (6 months)	2558.28	1644.94
Medical (12 months)	2172.84	1879.09
Kerosene (12 months)	1620.66	1306.58
Other non-food (12 months)	10993.52	3463.82

Panel D: Major activities by light sources

	Flashlight	Kerosene lanterns	Kerosene lamps
Reading/studying	0.04	0.98	0.98
Social interaction	0.13	0.17	0.22
Cooking/eating at night	0.01	0.15	0.98
Walking outside at night	0.86	0.48	0.68
Tending livestock	0.08	0.05	0.13
Income generating activities	0.02	0.00	0.00
Nightlight for security	0.72	0.23	0.30
No. of households	95	202	875

Table 2: Impacts on children's educational achievement: progression to the next grade

Dependent variable:	One if pass					
	December 2013			December 2014		
	LPM	LPM	Probit (ME)	LPM	LPM	Probit (ME)
	(a)	(b)	(c)	(d)	(e)	(f)
All products	0.022	0.023	0.024	-0.059	-0.058	-0.058
	(0.030)	(0.031)	(0.033)	(0.042)	(0.042)	(0.039)
One product	0.002	-0.003	-0.012	-0.024	-0.024	-0.022
	(0.026)	(0.028)	(0.026)	(0.038)	(0.038)	(0.036)
Age	-	0.011	0.014	-	0.005	0.006
		(0.015)	(0.015)		(0.015)	(0.014)
Education	-	0.211***	0.223***	-	-0.006	-0.007
(years)		(0.029)	(0.021)		(0.028)	(0.026)
Male	-	-0.035	-0.040	-	0.003	0.001
(dummy)		(0.032)	(0.037)		(0.062)	(0.058)
Household size	-	-0.016	-0.018	-	0.009	0.008
		(0.013)	(0.013)		(0.018)	(0.017)
No. of male members	-	-0.000	-0.000	-	-0.002	0.001
		(0.015)	(0.017)		(0.027)	(0.025)
Head age	-	-0.001	-0.002	-	-0.001	-0.001
(years)		(0.002)	(0.002)		(0.002)	(0.002)
Head education	-	0.002	0.002	-	0.007	0.007
(years)		(0.005)	(0.005)		(0.005)	(0.005)
Head male	-	0.040	0.034	-	0.120*	0.116**
(dummy)		(0.045)	(0.045)		(0.061)	(0.054)
Land size	-	0.001	0.001	-	-0.000	-0.000
(decimal)		(0.001)	(0.001)		(0.001)	(0.001)
All = one (p-val.)	0.485	0.417	0.243	0.389	0.419	0.343
All + one = 0 (p-val.)	0.612	0.700	0.824	0.236	0.241	0.219
R-squared	0.217	0.325	0.294	0.139	0.145	0.104
No. of obs.	850	850	754	845	845	832
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes
Mean y (control)	0.716	0.716	0.686	0.644	0.644	0.643

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade.

Table 3: Impacts on children's educational achievement: GPA z-scores (OLS)

Dependent variables:	GPA z-scores					
	Bengali	Bengali	English	English	Math	Math
	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)
December 2013						
All products	-0.046	-0.046	-0.053	-0.056	-0.052	-0.041
	(0.080)	(0.086)	(0.062)	(0.064)	(0.057)	(0.058)
One product	0.025	0.023	-0.129*	-0.136*	-0.081	-0.087
	(0.080)	(0.086)	(0.065)	(0.071)	(0.064)	(0.071)
All = one (p-val.)	0.369	0.434	0.330	0.350	0.669	0.546
All + one = 0 (p-val.)	0.881	0.878	0.079	0.077	0.192	0.233
Mean y (control)	-0.017	-0.017	0.014	0.014	0.009	0.009
R-squared	0.161	0.257	0.170	0.253	0.194	0.389
No. of obs.	850	850	850	850	850	850
Dependent variables:	General science	General science	Islam studies	Islam studies	Bangladesh general studies	Bangladesh general studies
	(1g)	(1h)	(1i)	(1j)	(1k)	(1l)
December 2013						
All products	0.048	0.052	0.049	0.055	0.070	0.066
	(0.084)	(0.084)	(0.079)	(0.082)	(0.067)	(0.070)
One product	0.039	0.037	0.016	0.020	0.126	0.121
	(0.076)	(0.078)	(0.077)	(0.079)	(0.084)	(0.089)
All = one (p-val.)	0.927	0.880	0.694	0.696	0.534	0.577
All + one = 0 (p-val.)	0.505	0.494	0.629	0.581	0.119	0.148
Mean y (control)	-0.035	-0.035	-0.041	-0.041	-0.067	-0.067
R-squared	0.183	0.297	0.167	0.257	0.143	0.270
No. of obs.	850	850	850	850	850	850
Dependent variables:	Bengali	Bengali	English	English	Math	Math
	(2a)	(2b)	(2c)	(2d)	(2e)	(2f)
December 2014						
All products	-0.095	-0.085	-0.047	-0.035	-0.112	-0.101
	(0.085)	(0.082)	(0.084)	(0.085)	(0.089)	(0.088)
One product	0.047	0.056	0.029	0.042	0.031	0.038
	(0.094)	(0.091)	(0.085)	(0.085)	(0.090)	(0.087)
All = one (p-val.)	0.075	0.061	0.364	0.334	0.138	0.141
All + one = 0 (p-val.)	0.766	0.853	0.901	0.960	0.599	0.674
Mean y (control)	0.024	0.024	0.012	0.012	0.030	0.030
R-squared	0.096	0.114	0.089	0.099	0.140	0.162
No. of obs.	846	846	846	846	846	846
Dependent variables:	General science	General science	Islam studies	Islam studies	Bangladesh general studies	Bangladesh general studies
	(2g)	(2h)	(2i)	(2j)	(2k)	(2l)
December 2014						
All products	-0.116	-0.102	-0.068	-0.059	-0.132	-0.126
	(0.084)	(0.082)	(0.092)	(0.088)	(0.092)	(0.091)
One product	-0.079	-0.063	0.023	0.041	-0.033	-0.022
	(0.092)	(0.091)	(0.099)	(0.098)	(0.094)	(0.090)
All = one (p-val.)	0.676	0.655	0.232	0.168	0.240	0.187
All + one = 0 (p-val.)	0.209	0.276	0.798	0.916	0.328	0.369
Mean y (control)	0.051	0.051	0.021	0.021	0.053	0.053
R-squared	0.128	0.148	0.090	0.107	0.109	0.127
No. of obs.	846	846	846	846	846	846
Baseline control	No	Yes	No	Yes	No	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table 4: Impacts on households' light sources and expenditures (OLS)

Dependent variables:	Per-day hours using light sources (sum of all owned & zero if not own)					
	Flashlight (rainy)	Flashlight (rainy)	Flashlight (off-rainy)	Flashlight (off-rainy)	Kerosene lanterns (rainy)	Kerosene lanterns (rainy)
	(a)	(b)	(c)	(d)	(e)	(f)
All products	-0.234***	-0.232***	-0.331***	-0.326***	-0.714***	-0.717***
	(0.073)	(0.072)	(0.106)	(0.104)	(0.103)	(0.114)
One product	-0.060	-0.057	-0.028	-0.028	-0.546***	-0.546***
	(0.090)	(0.088)	(0.134)	(0.128)	(0.110)	(0.116)
All = one (p-val.)	0.016	0.015	0.004	0.003	0.037	0.043
All + one = 0 (p-val.)	0.054	0.054	0.111	0.103	0.000	0.000
Mean y (control)	0.316	0.316	0.460	0.460	0.767	0.767
R-squared	0.052	0.060	0.061	0.069	0.148	0.179
No. of obs.	847	847	847	847	847	847
Dependent variables:	Per-day hours using light sources (sum of all owned & zero if not own)					
	Kerosene lanterns (off-rainy)	Kerosene lanterns (off-rainy)	Kerosene lamps (rainy)	Kerosene lamps (rainy)	Kerosene lamps (off-rainy)	Kerosene lamps (off-rainy)
	(g)	(h)	(i)	(j)	(k)	(l)
All products	-0.925***	-0.928***	-3.708***	-3.713***	-4.458***	-4.464***
	(0.117)	(0.126)	(0.194)	(0.188)	(0.270)	(0.256)
One product	-0.713***	-0.713***	-1.586***	-1.561***	-1.692***	-1.667***
	(0.129)	(0.131)	(0.210)	(0.201)	(0.213)	(0.206)
All = one (p-val.)	0.032	0.035	0.000	0.000	0.000	0.000
All + one = 0 (p-val.)	0.000	0.000	0.000	0.000	0.000	0.000
Mean y (control)	0.974	0.974	4.265	4.265	5.192	5.192
R-squared	0.145	0.170	0.459	0.484	0.448	0.468
No. of obs.	847	847	847	847	847	847
Dependent variables:	Log of expenditures					
	Education	Education	Kerosene	Kerosene	Total	Total
	(m)	(n)	(o)	(p)	(q)	(r)
All products	0.018	0.016	-1.301***	-1.313***	-0.055***	-0.059***
	(0.040)	(0.034)	(0.127)	(0.135)	(0.020)	(0.014)
One product	0.004	0.036	-0.693***	-0.686***	-0.032*	-0.016
	(0.052)	(0.049)	(0.069)	(0.072)	(0.018)	(0.017)
All = one (p-val.)	0.791	0.659	0.000	0.000	0.361	0.035
All + one = 0 (p-val.)	0.772	0.476	0.000	0.000	0.003	0.002
Mean y (control, not log)	3135.69	3135.69	1600.50	1600.50	81279.41	81279.41
R-squared	0.115	0.220	0.417	0.439	0.091	0.474
No. of obs.	842	842	631	631	847	847
HH baseline control	No	Yes	No	Yes	No	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each village. (3) The baseline controls include household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table 5: Impacts on children's educational inputs: study time (OLS)

Dependent variable:	Per-day minutes (average from Sep 2013 to Apr 2014) spent on:					
	Study at school	Study at home				Other activities
		total	day	night	under kerosene lamps	
	(a)	(b)	(c)	(d)	(e)	(f)
With no baseline controls						
All products	1.263	11.527**	-7.996***	19.523***	-105.801***	-4.531
	(3.049)	(5.439)	(2.807)	(3.512)	(3.247)	(10.997)
One product	2.913	18.865***	-5.522*	24.387***	-104.483***	-5.565
	(3.354)	(6.059)	(2.812)	(3.718)	(3.265)	(9.971)
All = one (p-val.)	0.668	0.160	0.436	0.084	0.523	0.906
All + one = 0 (p-val.)	0.422	0.005	0.006	0.000	0.000	0.600
R-squared	0.122	0.146	0.183	0.198	0.821	0.445
No. of obs.	620	620	620	620	620	620
	(g)	(h)	(i)	(j)	(k)	(l)
With baseline controls						
All products	1.643	12.950**	-7.029**	19.979***	-105.381***	-4.968
	(3.148)	(5.600)	(2.825)	(3.544)	(3.263)	(10.826)
One product	2.903	19.025***	-5.097*	24.122***	-104.529***	-7.378
	(3.449)	(5.979)	(2.749)	(3.653)	(3.348)	(9.332)
All = one (p-val.)	0.739	0.263	0.537	0.162	0.666	0.804
All + one = 0 (p-val.)	0.407	0.003	0.012	0.000	0.000	0.490
R-squared	0.137	0.173	0.212	0.221	0.825	0.451
No. of obs.	620	620	620	620	620	620
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes
Mean y (control)	197.72	229.54	110.75	118.78	111.03	847.61

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number). (4) Other activities include sports, cooking and bathing, household chores, and some other activities, including sleeping and rest.

Table 6: Impacts on children's educational inputs: school attendance (OLS)

Dependent variable:	One if attend			
Timing of visit in 2014:	Feb	April	August	Any
	(a)	(b)	(c)	(d)
With no baseline controls				
All products	0.110***	0.097**	0.043	0.084***
	(0.040)	(0.036)	(0.031)	(0.025)
One product	0.043	0.089**	0.005	0.045*
	(0.038)	(0.041)	(0.032)	(0.024)
Visit in April	-	-	-	-0.083**
				(0.033)
Visit in August	-	-	-	0.002
				(0.057)
All = one (p-val.)	0.133	0.827	0.216	0.108
All + one = 0 (p-val.)	0.022	0.008	0.387	0.004
R-squared	0.180	0.188	0.208	0.112
No. of obs.	882	882	882	2646
	(e)	(f)	(g)	(h)
With baseline controls				
All products	0.104**	0.093**	0.035	0.077***
	(0.039)	(0.037)	(0.031)	(0.025)
One product	0.043	0.087**	0.002	0.044*
	(0.037)	(0.042)	(0.032)	(0.024)
Visit in April	-	-	-	-0.083**
				(0.033)
Visit in August	-	-	-	0.002
				(0.057)
All = one (p-val.)	0.176	0.887	0.295	0.153
All + one = 0 (p-val.)	0.024	0.012	0.496	0.007
R-squared	0.241	0.228	0.253	0.155
No. of obs.	882	882	882	2646
School FE	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes
Mean y (control)	0.561	0.481	0.589	0.544

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table 7: Children's educational efficiency (OLS)

Dependent variable:	One if pass		
	December 2014		
	(a)	(b)	(c)
All products	-	-0.062	-0.640*
		(0.049)	(0.351)
One product	-	-0.017	-0.446
		(0.051)	(0.346)
Study at school	-0.001	-0.001	-0.001
(per-day minutes)	(0.001)	(0.001)	(0.001)
Study at home	0.000	-0.000	-0.001
(day, per-day minutes)	(0.001)	(0.001)	(0.001)
Study at home	0.000	0.001	0.001
(night, per-day minutes)	(0.001)	(0.001)	(0.001)
One if attend	0.073	0.078	0.033
(February)	(0.048)	(0.047)	(0.078)
One if attend	-0.072*	-0.069*	-0.076
(April)	(0.038)	(0.037)	(0.054)
One if attend	0.010	0.010	-0.073
(August)	(0.038)	(0.039)	(0.056)
All products			
× Study at	-	-	0.001
school			(0.001)
× Study at	-	-	0.005**
home (day)			(0.002)
× Study at	-	-	-0.002
home (night)			(0.002)
× One if attend	-	-	0.110
(February)			(0.133)
× One if attend	-	-	0.008
(April)			(0.075)
× One if attend	-	-	0.085
(August)			(0.099)
One product			
× Study at	-	-	0.000
school			(0.002)
× Study at	-	-	-0.001
home (day)			(0.003)
× Study at	-	-	0.002
home (night)			(0.002)
× One if attend	-	-	0.177
(February)			(0.120)
× One if attend	-	-	-0.028
(April)			(0.125)
× One if attend	-	-	0.214**
(August)			(0.088)
R-squared	0.157	0.159	0.184
No. of obs.	617	617	617
Baseline control	No	No	No
School FE	Yes	Yes	Yes
Village FE	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade.

Supplemental appendix

S.1 Cost-effectiveness analysis of solar lanterns on school attendance

To further assess the estimated impacts on school attendance, we carried out a cost-effectiveness analysis, following the method used by Dhaliwal et al. (2013) and Evans and Popova (2016). Table S.15 in this supplemental appendix reports on additional years of education per 100 USD, based on the estimated treatment effects reported in columns (d) and (h) in Table 6 in the article. To simplify the analysis, we considered only the cost (prices) of the solar lanterns, ignoring other factors such as research administration costs, reduced kerosene expenditure, and product maintenance opportunity costs. Assuming that the life of a solar lantern is five years, the minimum length of time for which products function effectively in normal conditions, we divided the product prices by five to estimate annual product costs. Table S.15 shows that our intervention raised student participation by 0.59 and 0.64 years per 100 USD spent with and without baseline control.[23] This table also shows that providing a bundle of three lanterns is more cost effective than providing only one solar lamp; however, the estimated solar impacts were only marginally different between the two cases at 10—15% significance levels, as reported in Table 6 in the article. While the impact of our intervention did not last long, this increase of 0.59—64 years per 100 USD still seems remarkable. Referring to Evans and Popova (2016) (Table 3 in p. 268), this increase can be compared with that revealed in Evans et al. (2008)'s study, which involved distributing school uniforms in Kenya.

S.2 Discussion: does complementarity matter?

A growing body of empirical research has suggested that relaxing only one educational constraint may not result in children's improved school outcomes in the developing world (e.g., Glewwe et al. 2004; Glewwe et al. 2009; Mo et al. 2013). Given that solar lamps were also expected to address only one factor that encouraged children's human capital acquisition, i.e., better nighttime lighting for home study, our findings are consistent with those provided by recent studies. Our findings are also in line with the experimental study conducted in Uganda by Furukawa (2014), who also revealed no improvement in school exam outcomes despite the increased study time induced by the provision of solar lanterns.[24]

Complementarity across educational inputs (e.g., textbooks, teacher quality, and home-study support) may play an important role in determining academic performance. For example, in the estimations of school attendance performed in Table 6 in the article, we saw statistically significant increases in school attendance in the first two visits for the treated students (mainly for those who received all three solar products). However, during the final visit in August,

[23] More precisely, these figures came to:
$\left(\text{solar impacts} \times \text{no. of treated students}\right) \div \left(\frac{\text{product prices (USD)}}{\text{5 years}} \times \text{no. of treated students}\right) \times 100$ USD.

[24] Furukawa (2014) indicated that the malfunctioning of the solar products (due to flickering and failure to fully recharge the unit) might have made nighttime study virtually impossible for the treated students, thus resulting in an insignificant impact. However, our counterpart NGO, which had continuous contact with the subjects in the studied area, did not report this problem.

it was found that this initial enthusiasm for school attendance prompted by solar lanterns disappeared. Moreover, we found that other educational inputs, measured by the education-related expenditures, were similar among the treatment and control groups, despite the improved savings on kerosene consumption by the treated households (see Table 4 in the article, columns (m) and (n)).[25] These findings may suggest that the increased educational demand was not sufficiently met by the better learning inputs provided to the treated students by their households, schools, and teachers. Therefore, the increased study hours and improvements in initial school attendance did not translate into improved academic performance.[26]

To analyze complementarity further, we collected information on school inputs and explored the heterogeneity of treatment effects on student progress in these dimensions - see Table S.20 in this supplemental appendix. The information we used included the number of students in each school grade in columns (a) and (g) and several school-level inputs in the remaining columns.[27] As the data on the school-level inputs reflected a situation *after* a follow-up survey, and varied only by the number of schools participating in our project (i.e., 17 schools), the estimation results should be interpreted in light of these limitations. Along with similar estimation results of each subject's GPA scores, as reported in Table S.21 to S.26, no distinct treatment heterogeneity was observed. It is also worth remembering that no discernible treatment heterogeneity was found across several family characteristics, as seen in Table S.5 (for progression) and Table S.6 to S.11 (for GPA scores).

On one hand, the finding that treatment effects do not vary by educational inputs on either the demand- or the supply-side of educational production may appear to undermine the view that complementarity matters. However, the absence of treatment heterogeneity may simply suggest that, in the ultra-poor setting of our study, the quality of other educational inputs was also low; the low quality therefore did not make any noticeable difference in the treatment effects. For example, approximately 80% of household heads had no education (at baseline), with a mean value of 1.27 years (std. 2.83 years) as well as a median of zero years. The high failure rate of students trying to move up to the next grade (reported at the bottom of Table 2 in the article) also suggests that our chosen site had many education-related constraints (e.g., ultra-poor families, the limited availability of good teachers). The latter interpretation is consistent with the aforementioned view that solar-induced educational demand among treated students (e.g., an increase in school attendance) was not sufficiently met by families, schools, or teachers.

In conclusion, it is difficult to prove or disprove the importance of complementarity between solar lamps and other

[25] These education-related expenditures include fees relevant to admission, tuition, examinations, and private schooling; school material costs (e.g., books and pens); and transportation and food expenses.

[26] Alternatively, the treated students might have regularly attended school in the initial months because they anticipated that they might receive some additional treatments in the future if they showed high attendance records. However, it may be that it took several months for them to realize that no additional support was coming from our counterpart NGO. Hence, they changed their expectations and eventually behaved similarly to the children who belonged to the control group.

[27] The number of students in each school grade was based on the 1,665 students enrolled in the 4^{th} to 8^{th} grades at 17 sample schools participating in our experiment. Consequently, this number slightly exceeded the number of students who regularly attended school, because the 1,665 students included some with an attendance rate lower than 80% in the last four months (see Section I in the article).

education-related inputs from a single study that was not designed to explore this particular aspect.[28] Therefore, our findings may still imply that the solar lanterns had a limited impact on children's academic performance, while other education-related inputs remained constant. While this may not be the only reason for the sizable impacts of solar lamps on educational inputs but not on achievement, the empirical results should still be considered of the first order of importance, and future research should aim to validate this educated conjecture.[29]

S.3 Threats to statistical inference

This section discusses several threats to the findings of this study.

S.3.1 Bounds on treatment effects

While the number of households lost in the follow-up survey – due to attrition – was small, the sample selection associated with the missing outcome data remains an empirical concern. A possible solution to this problem is to use a selection correction methodology by explicitly modeling the selection process. However, this approach cannot be adopted in the current research due to difficulties in precisely modeling the selection mechanisms and the lack of effective instruments that would explain the selection but not the outcomes.

As an alternative, we estimated the bounds of the treatment effects, based on Lee (2009)'s methodology. However, it is acknowledged that this approach is not free from limitations. First, it has to be assumed that the treatment assignment monotonically affects the selection, which cannot clearly be tested. Second, the estimates are the treatment effects on the sub-population that would always be observed regardless of the treatment assignment; however, they may not always be the main interest of the study. Nevertheless, it remains useful to assess the already identified estimates based on this approach.

First, Lee (2009) demonstrated that in randomized experimental settings, if the sample attrition rates are similar between the treatment and control groups, a simple comparison between these groups can still be interpreted as a valid average treatment effect on the aforementioned local population. With controls of the baseline family characteristics and village-fixed effects, Table S.27 in this supplemental appendix reports the impacts of the solar products on the non-attrition probability (which is one if the outcome data are not missing at follow-up) for the relevant previously estimated outcomes.[30] Based on the results, we can see, for example, that the treatment groups were more likely to provide missing information on kerosene expenditure in the follow-up survey than the control groups. This is

[28]For example, other school inputs not explored here may play a significant role in improving students' performance.

[29]Another possible explanation is that our target population might have been too young to enjoy a noticeable improvement in academic performance (e.g., Stinebrickner and Stinebrickner, 2008).

[30]Notably, the estimation results of school attendance, reported in Table 6 in the article are free from the selection problem because the analysis exploited the data that pertained to all 882 respondents.

probably due to their replacement of kerosene lighting sources with solar products. However, in most cases, the results reported in Table S.27 provide no strong evidence that indicates significant effects of the treatment assignment on the non-attrition group probability.

Pooling the two treatment groups into one for reasons of computation, Table S.28 presents 95% confidence intervals of the treatment effects based on Lee (2009)'s approach. As no controls were exploited in this analysis, the confidence intervals are quite wide. Nevertheless, it appears that the results provide similar implications to those findings obtained from the earlier analysis in this paper.

S.3.2 Spillover effects

The potential for spillover effects is another empirical challenge that we faced in this study. As the randomization was carried out within a specific grade level at each sample school, it is certainly possible that a student who did not receive solar products could have benefited from her friends who did receive the products, or from having access to SHSs for nighttime study. However, visiting a friend's home at night in *unelectrified river islands* is quite risky, for both boys and girls. In fact, in a follow-up household survey, we collected information on whether treated students shared solar lamps with non-household members, and identified only three such cases, where solar lamps were shared with cousins. Hence, this possibility may not have been a valid concern in our setting.

Other spillover effects could have resulted from interactions in school and during exams. Non-treated students could have learned from their treated peers in school, minimizing the difference in outcomes between the treatment and control groups. However, if such spillover effects artificially blurred the academic performance gap between the treatment and control groups, they also may have made it difficult to detect significant differences in educational inputs among students. Finding significant increases in study time and school attendance among treated students could reduce this concern. However, it is still important to consider this possibility more carefully.[31]

Two exercises were conducted. First, we collected information on the average progression rates in one of the studied districts, Kurigram, in 2012, 2013, and 2014; these were 0.93, 0.98, and 0.97 for primary-school students and 0.83, 0.89, and 0.86 for secondary-school students, respectively (i.e., a marginal increase in the progression rate from 2012 to 2014). In our control group, the progression rates in 2012, 2013, and 2014 were 0.80, 0.78, and 0.70 for 4^{th} to 5^{th} grade students and 0.67, 0.64, and 0.58 for 6^{th} to 8^{th} grade students, respectively (i.e., a decline in the progression rate from 2012 to 2014). Thus, we have no evidence to suggest that, on average, the academic performance of our control students improved in a more pronounced way during the sample periods than did the performance of all the

[31] On the other hand, it is also possible that the control students were disappointed at losing the lottery, and therefore did not study as hard during the sample periods. This possible discouraging effect (if any) would have led us to overestimate the treatment effects on children's educational achievement. If so, the true performance impact of solar products would be smaller than current estimates, while further supporting the result of "no academic performance effects" found with modern lighting technology.

Kurigram students.

Second, we exploited the insight obtained from Baird et al. (2014) that the fraction of those offered treatment in a cluster (i.e., treatment saturation) could be used to estimate the spillover effects on the non-treated population. Recall from Section I in the article that in the 17 sample schools that participated in our experiment, 1,665 students were enrolled in the 4^{th} to 8^{th} grades. We initially selected 1,292 children (belonging to 1,292 different households) among these students. The remaining 373 students were excluded, either because they were known to have access to electricity, because a sibling was one of the 1,292 students (in each household, only one child was included in our study sample), or because they were not considered regular students because their school attendance had been lower than 80% during the last four months. From these 1,292 students, we further excluded 381 students who were found to have access to electricity, when the research team visited their homes, resulting in 911 target students, which eventually turned into 882 effective sample students.

Consequently, each grade at each school potentially consisted of four types of students: (whether treated or not) our study sample, their siblings, those with access to electricity at the baseline, and those with poor attendance. This experimental design enabled us to explore whether the fraction of treated students and their siblings in each school grade (i.e., treatment intensity) influenced the students' educational achievement, after controlling for the school grade fraction of regularly attending students with no access to electricity at the baseline (i.e., eligible fraction), whereby both fractions varied across grades within a school. Note that the latter fraction was endogenous. However, given this control, the former fraction was expected to have random variation. This approach is similar to that adopted by Miguel and Kremer (2004) and Oster and Thornton (2012). Having no statistically significant relationship between treatment intensity and educational achievement reduces any concern about spillover effects.[32]

To calculate the aforementioned fractions, we needed to know exactly why the 373 students were excluded during the first screening process, as well as the treatment status of their sibling if that sibling was eventually part of our study sample. Unfortunately, this information was not collected. We therefore considered the following four distinctive scenarios: (Case A) all 373 students had a sibling belonging to our treatment sample; (Case B) all 373 students had a sibling belonging to our control sample; (Case C) all 373 students had access to electricity at the baseline; and (Case D) none of the 373 students were regularly attending school. The treatment intensity takes the mean values of 0.49 (std. 0.09), 0.27 (std. 0.04), 0.27 (std. 0.04), and 0.36 (std. 0.05) in Case A, Case B, Case C, and Case D, respectively, along with the eligible fraction taking the mean values of 0.77 (std. 0.09), 0.77 (std. 0.09), 0.55 (std. 0.09), and 0.71 (std. 0.10), corresponding to each of the four cases.[33] Acknowledging its limitations, considering these cases, and

[32]We are grateful to one anonymous referee for recommending this exercise.

[33]The maximum (minimum) value of the treatment intensity was 0.71 (0.23), 0.38 (0.04), 0.38 (0.13), and 0.50 (0.18) in Case A, Case B, Case C, and Case D, respectively. Similarly, the maximum (minimum) value of the eligible fraction was 1.00 (0.50), 1.00 (0.50), 0.77 (0.23), and 1.00 (0.31) in Case A, Case B, Case C, and Case D, respectively. Note that in order to calculate the treatment intensity, we included only students who regularly attended school in the total number of students in each school grade (i.e., the denominator).

checking the sensitivity of the analytical results may help to ensure that the present investigation remains useful.

The estimation results corresponding to the above four scenarios were reported in the second and third panels of Table S.29 (for progression) and Table S.30 to Table S.33 (for GPA scores) in this supplemental appendix. Considering all these estimation results, there is no strong evidence to suggest that the "no academic performance effects" of solar lamps should be attributed to a positive learning externality. Note that the absence of spillover effects is consistent with both views - that learning interaction between the treated and remaining students existed or did not exist. Given the absence of significant treatment effects, the former case may suggest that solar lamps did not provide treated students with any educational benefits (in terms of performance) that could have been transferred from them to the remaining students.

Finally, as the measured treatment intensity is unavoidably imprecise, for the reasons mentioned above, it may not be seen as strictly exogenous, even if the estimated eligible fraction is controlled for. To somewhat alleviate this concern, we also collected information on students' academic performance in the final examination held in December 2012; we checked for a relationship between this pre-experiment test result and the subsequent treatment intensity in the first panel of Table S.29 (for progression) and Table S.30 to Table S.33 (for GPA scores). This falsification test revealed no relationships that were noticeable in a statistical sense, thereby arguably supporting the assumption that measured treatment intensity has exogenous variation (given the control of the eligible fraction).

S.3.3 Floods

One remaining concern for the 2014 examination results is that continuous rainfall struck northern Bangladesh in August 2014, causing flash floods in our study area. Consequently, some families sought shelter during that time. This weather shock may explain no improvement of academic performance attributed to the provision of solar products. This is possible if this (only) temporary shock was sufficiently large to make the subsequent learning of all the sample students indiscriminate.

However, this study sees this concern as less likely for several reasons. First, apparently, the proportion of people that evacuated to shelters was not so remarkably large. Based on Martin (2014), for example, the population targeted due to this flood by aid agencies for humanitarian assistance was only less than 12% of the vulnerable population (i.e., extremely poor people) in the affected district.[34] In fact, during our school visit in August, when the area was already affected by the flood, the rate of children's attendance (i.e., 61.7%) was comparable to that in the remaining visits (61.5% and 52.7% in February and April, respectively). Notably, while only less vulnerable students might have remained in school in August, such family characteristics are likely to be orthogonal to the treatment status, which

[34] See also `http://reliefweb.int/disaster/fl-2014-000117-bgd` for the flood issues.

is uncorrelated with the exogenous climate shock. Second, the school operation interrupted during the flood settled down immediately after the water receded in September. Third, the residents of *Char* areas are quite accustomed to this monsoon-based flash flooding as well as to the associated temporary displacement that occurs regularly in these areas.

Finally, to mitigate this concern of the flood effect, we also made every effort to collect children's scores on the mid-term examination, a non-mandatory exam that aims to conduct a learning regularity check on the enrolled students, which was held in June 2014 before the floods occurred. Table S.34 in this supplemental appendix reports the treatment effects of solar products on the test scores of each subject (GPA z-scores). Unfortunately, the relevant information could only be collected from some of the sample students.[35] Acknowledging a sample selection problem that might have affected the estimation results for this reason, our headline finding – "no academic performance effects" of solar lanterns – remains the same.

S.3.4 Multiple-hypothesis testing

In this study exploring the impacts of two treatment arms on multiple outcomes, we may accidentally have found statistically significant treatment effects for some arms and outcomes, even where true causal effects were absent (e.g., List et al., 2015). While this concern about multiple-hypothesis testing does not affect the key finding, "no academic performance effects," it is still important to consider this issue for the remaining outcomes.

Two common approaches exist to address the multiple-inference problem (e.g., Schochet, 2008). The first is to reduce the number of tests being performed. Accordingly, we merged two treatment arms into one, re-examining only the selected outcomes reported in Table S.35 in this supplemental appendix. Moving up to the next grade may be seen as a summary index that reflects all test scores [columns (a)—(b)]. In addition, when analyzing the average hours of use of lighting products, rainy and off-rainy seasons are aggregated into one season [columns (c)—(e)]. The three school visits in February, April, and August are also jointly analyzed in column (n), as they were in columns (d) and (h) in Table 6 in the article. This procedure resulted in 14 tests being conducted in Table S.35.

The second approach is to adjust the p-values. Table S.35 reports the (pooled) treatment effects, the original p-values, and the adjusted p-values estimated using a well-known Bonferroni procedure and Holm (1979)'s step-down adjustment procedure.[36] Since these procedures do not account for a dependency structure across tests when controlling a familywise error rate, they tend to reveal low statistical power.[37][38] Nevertheless, significant solar impacts

[35] The relevant information was available only for 5^{th}—8^{th} grade students at one school and 4^{th} grade students in all the primary schools, who attended the examinations.

[36] We exploited a *Stata* command `qqvalue` developed by Newson (2010) to calculate these adjusted p-values.

[37] An alternative approach is to control the false discovery rate (e.g., Anderson, 2008; Benjamini et al., 2006). Controlling the familywise error rate is a more conservative approach than controlling the false discovery rate.

[38] As an approach to controlling the familywise error rate becomes more conservative, it loses more statistical power (e.g., Blakesley et al., 2009; Sankoh et al., 1997).

are observed in relation to the time spent using kerosene lanterns/lamps, kerosene-related and total expenditure, study time at home, and school attendance. Overall, the previous findings are robust in their consideration of multiple-hypothesis testing.

S.4 Supplemental figures and tables

Figures and tables provided in this supplemental appendix are as follows.

- Figure S.1: Product pictures.
- Figure S.2: Timeline of interventions and surveys.
- Figure S.3: Sample of a time diary.
- Table S.1: The number of students selected in each screening process.
- Table S.2: Summary statistics at baseline.
- Table S.3 and Table S.4: Balance tests across treatment conditions.
- Table S.5 to Table S.11: Heterogeneous treatment effects on children's educational achievement.
- Table S.12: Impacts on households' willingness to buy solar products.
- Table S.13: In this table, we disaggregated treatment effects on students' time spent on "other activities" (that were examined in columns (f) and (l) in Table 5 in the article) into "sports," "cooking and bathing," "household chores," and "other activities, including sleeping and rest."
- Table S.14: By treatment arms, this table provides similar information to that reported in Table 1 in the article, collected during a follow-up household survey.
- Table S.15: Cost-effectiveness of solar lanterns on school attendance.
- Table S.16: Heterogeneous treatment effects on children's educational inputs.
- Table S.17 to Table S.19: In these tables, a similar analysis to that conducted for students' progression to the next grade in Table 7 in the article was performed to examine the relationship between educational inputs and GPA scores.
- Table S.20 to Table S.26: Complementarity between solar lamps and school inputs in explaining children's educational achievement.

- Table S.27: Estimating non-attrition probability.
- Table S.28: Lee (2009)'s 95% confidence intervals of the treatment effects.
- Table S.29 to Table S.33: Checking on spillover effects on children's educational achievement.
- Table S.34: Impacts on children's mid-term examination results.
- Table S.35: Checking on multiple-hypothesis testing.

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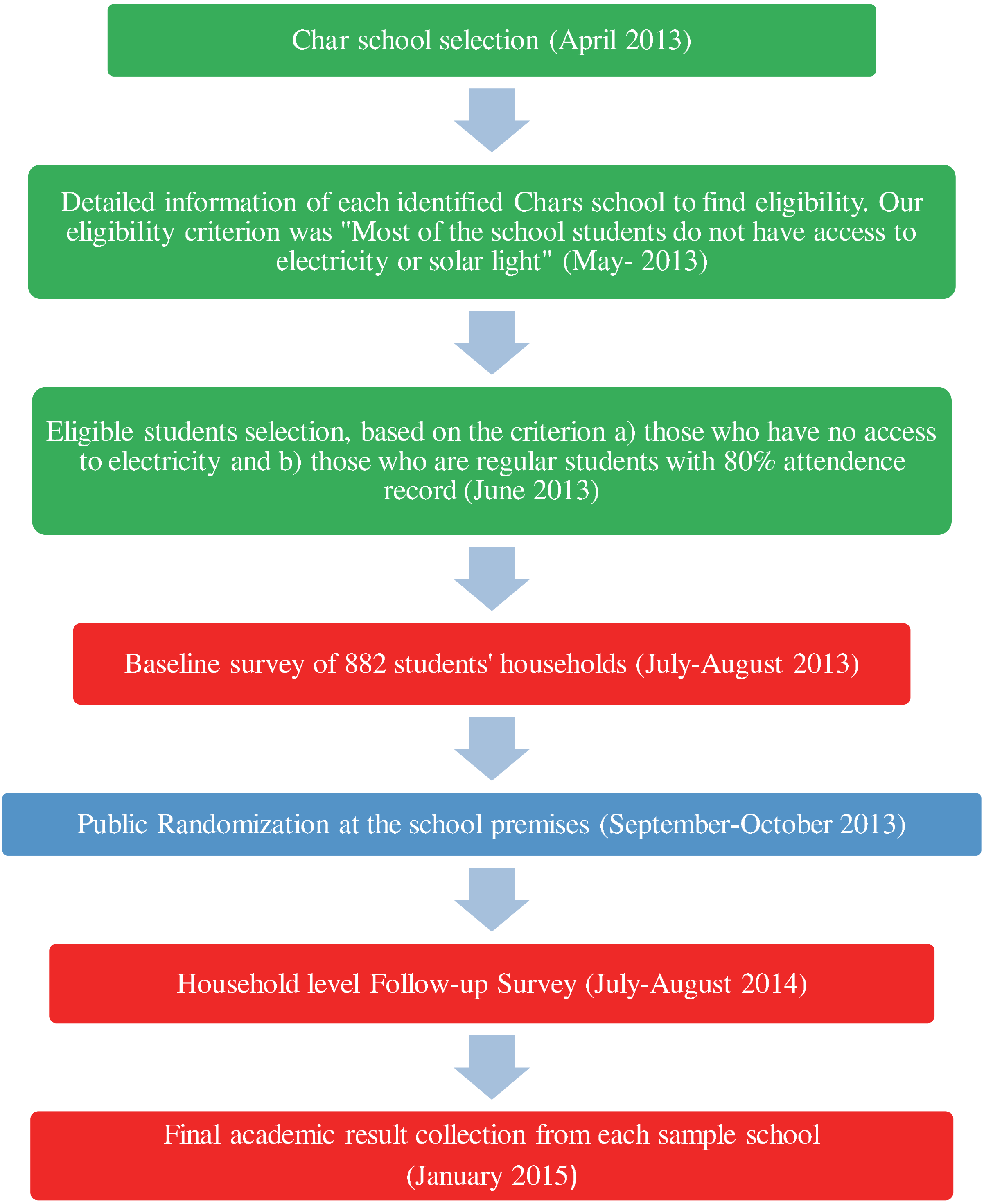
Figure S.1: Product pictures

Note: The S250, S10, and S2 are displayed in order from the left.



Source: Prepared by the authors. The blue panels show events regarding interventions, red panels show events regarding surveys and the green panels show events regarding sample selection.

Figure S.2: Timeline of interventions and surveys

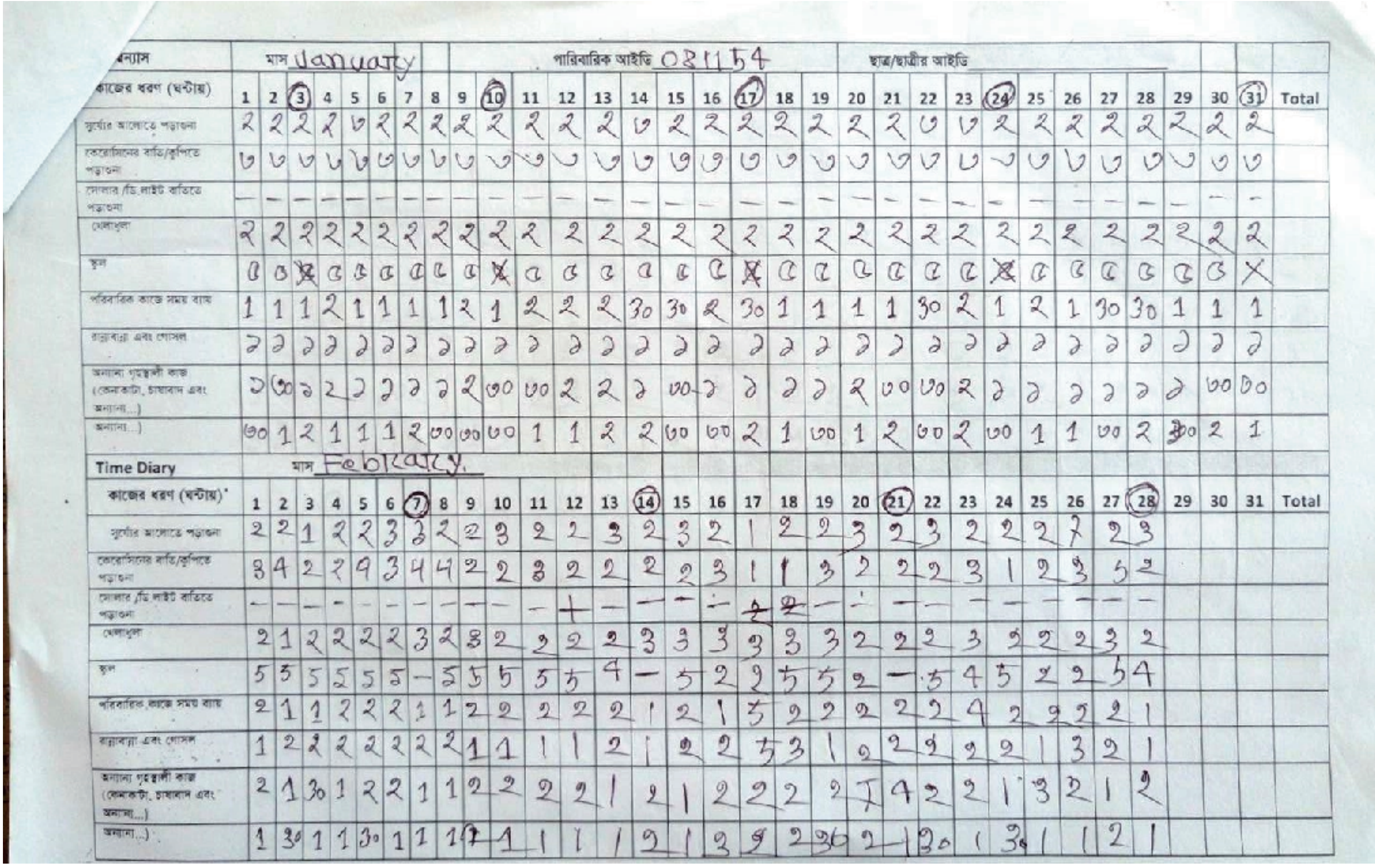


Figure S.3: Sample of a time diary

Table S.1: The number of students selected in each screening process

School (grade)	No. of schools	No. of students						
		enrolled	initially eligible	eventually eligible	in our study	treated (all)	treated (one)	controlled
Primary (4^{th} to 5^{th})	12	823	638	452	438	120	98	220
Junior high (6^{th} to 8^{th})	5	842	654	459	444	128	100	216
Total	17	1665	1292	911	882	248	198	436

Table S.2: Summary statistics (baseline)

	Treatment A (248 households)		Treatment B (198 households)		Control (436 households)		All	
	Mean	Std.	Mean	Std.	Mean	Std.	Mean	Std.
Panel A: Student-level variables (one sample student from each household)								
Age (years)	12.34	1.55	12.46	1.61	12.36	1.46	12.38	1.52
Male (dummy)	0.41	0.49	0.42	0.49	0.45	0.49	0.43	0.49
Education (years)	4.64	1.38	4.63	1.42	4.59	1.39	4.61	1.39
Panel B: Household-level variables								
Household size	4.94	1.37	4.78	1.10	4.94	1.30	4.90	1.28
No. of males	2.40	1.14	2.30	0.98	2.49	1.12	2.42	1.10
Head age (years)	41.84	9.19	41.98	8.10	41.67	8.49	41.79	8.60
Head education (years)	1.18	2.66	1.19	2.79	1.34	2.94	1.26	2.83
Head male (dummy)	0.91	0.27	0.92	0.25	0.91	0.28	0.91	0.27
Land size (decimal)	10.32	34.58	10.47	21.02	9.82	22.12	10.11	25.99

Table S.3: Balance test across treatment conditions

	Treatment A		Treatment B		R-sqd.	No.
Dependent variables:	Coefficient	Std. errors	Coefficient	Std. errors		of obs.
Panel A: Student-level variables (one experimented student for one household)						
Age (years)	-0.020	(0.145)	0.098	(0.134)	0.002	882
Male (dummy)	-0.045	(0.052)	-0.027	(0.043)	0.000	882
Education (years)	0.051	(0.096)	0.037	(0.115)	0.002	882
Panel B: Household-level variables						
Household size	0.007	(0.088)	-0.152**	(0.061)	0.003	882
No. of males	-0.084	(0.069)	-0.183**	(0.076)	0.004	882
Head age (years)	0.175	(0.690)	0.318	(0.699)	0.000	882
Head education (years)	-0.159	(0.242)	-0.147	(0.222)	0.001	882
Head male (dummy)	0.005	(0.028)	0.019	(0.023)	0.001	882
Land size (decimal)	0.495	(2.781)	0.647	(1.837)	0.000	882

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each village.

Table S.4: Additional balance tests across treatment conditions (OLS)

Dependent variables:	One if Treatment A	One if Treatment B	One if Treatment A	One if any treatment
Sample:	Treatment A & Control	Treatment B & Control	Treatment A & Treatment B	All
	(a)	(b)	(c)	(d)
Age	-0.016	0.012	-0.027	-0.004
	(0.019)	(0.019)	(0.020)	(0.017)
Education	0.019	-0.002	0.020	0.011
(years)	(0.012)	(0.019)	(0.020)	(0.014)
Male	-0.020	0.015	-0.033	-0.004
(dummy)	(0.050)	(0.046)	(0.040)	(0.050)
Household size	0.007	-0.014	0.019	-0.002
	(0.021)	(0.018)	(0.020)	(0.019)
No. of male members	-0.022	-0.037	0.020	-0.033
	(0.024)	(0.023)	(0.028)	(0.022)
Head age	0.000	0.001	-0.000	0.001
(years)	(0.002)	(0.002)	(0.003)	(0.002)
Head education	-0.005	-0.004	-0.000	-0.006
(years)	(0.007)	(0.006)	(0.008)	(0.006)
Head male	0.022	0.105	-0.092	0.065
(dummy)	(0.091)	(0.067)	(0.116)	(0.069)
Land size	0.000	0.000	-0.000	0.000
(decimal)	(0.001)	(0.001)	(0.001)	(0.001)
All coefficients = zero (p-values)	0.724	0.011	0.119	0.323
R-squared	0.005	0.013	0.010	0.007
No. of obs.	684	634	446	882

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each village.

Table S.5: Impacts on children's educational achievement: heterogeneity (OLS)

Dependent variable:	One if pass								
X:	Age	Education	Male	Household size	No. of male members	Head age	Head education	Head male	Land size
	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)	(1g)	(1h)	(1i)
December in 2013									
All products	-0.314	0.013	0.046	0.036	0.097	0.113	0.022	0.076	0.035
	(0.284)	(0.115)	(0.041)	(0.121)	(0.071)	(0.172)	(0.036)	(0.095)	(0.034)
One product	-0.043	0.047	-0.022	0.059	0.097*	-0.010	-0.004	0.045	0.010
	(0.245)	(0.091)	(0.047)	(0.119)	(0.057)	(0.149)	(0.029)	(0.123)	(0.025)
All products × X	0.027	0.002	-0.056	-0.003	-0.030	-0.002	0.000	-0.059	-0.001
	(0.022)	(0.021)	(0.061)	(0.022)	(0.026)	(0.004)	(0.014)	(0.098)	(0.001)
One product × X	0.003	-0.011	0.046	-0.013	-0.043*	0.000	0.001	-0.053	-0.001
	(0.020)	(0.022)	(0.065)	(0.026)	(0.025)	(0.004)	(0.012)	(0.136)	(0.002)
R-squared	0.326	0.325	0.326	0.325	0.327	0.325	0.325	0.325	0.326
No. of obs.	850	850	850	850	850	850	850	850	850
	(2a)	(2b)	(2c)	(2d)	(2e)	(2f)	(2g)	(2h)	(2i)
December in 2014									
All products	-0.701**	-0.253*	0.016	-0.309*	0.004	-0.123	-0.094*	-0.022	-0.054
	(0.289)	(0.128)	(0.053)	(0.168)	(0.093)	(0.175)	(0.047)	(0.147)	(0.050)
One product	-0.281	-0.019	-0.020	-0.073	0.043	-0.207	-0.043	0.011	-0.042
	(0.309)	(0.126)	(0.052)	(0.152)	(0.098)	(0.223)	(0.039)	(0.173)	(0.042)
All products × X	0.052**	0.042	-0.173*	0.051*	-0.025	0.002	0.028*	-0.039	-0.000
	(0.023)	(0.028)	(0.093)	(0.030)	(0.032)	(0.004)	(0.015)	(0.143)	(0.001)
One product × X	0.021	-0.001	-0.005	0.010	-0.028	0.004	0.013	-0.039	0.002
	(0.024)	(0.023)	(0.068)	(0.031)	(0.038)	(0.005)	(0.013)	(0.187)	(0.002)
R-squared	0.150	0.148	0.151	0.149	0.146	0.146	0.150	0.145	0.147
No. of obs.	845	845	845	845	845	845	845	845	845
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.6: Impacts on children's educational achievement - Bengali: heterogeneity (OLS)

Dependent variable:	Bengali: GPA z-scores								
X:	Age	Education	Male	Household size	No. of male members	Head age	Head education	Head male	Land size
	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)	(1g)	(1h)	(1i)
December in 2013									
All products	-0.208	0.184	-0.115	0.359	0.274	0.361	-0.036	0.289	-0.048
	(0.777)	(0.312)	(0.105)	(0.280)	(0.188)	(0.405)	(0.095)	(0.258)	(0.092)
One product	-0.005	0.284	-0.013	0.195	0.064	-0.581*	0.046	0.222	0.017
	(0.800)	(0.300)	(0.111)	(0.283)	(0.199)	(0.330)	(0.086)	(0.224)	(0.094)
All products × X	0.013	-0.050	0.161	-0.082	-0.132*	-0.010	-0.008	-0.368	0.000
	(0.060)	(0.059)	(0.176)	(0.052)	(0.071)	(0.009)	(0.036)	(0.265)	(0.002)
One product × X	0.002	-0.057	0.082	-0.035	-0.015	0.014*	-0.018	-0.217	0.001
	(0.065)	(0.064)	(0.148)	(0.053)	(0.073)	(0.007)	(0.031)	(0.227)	(0.003)
R-squared	0.257	0.258	0.258	0.259	0.261	0.262	0.257	0.259	0.257
No. of obs.	850	850	850	850	850	850	850	850	850
	(2a)	(2b)	(2c)	(2d)	(2e)	(2f)	(2g)	(2h)	(2i)
December in 2014									
All products	-0.491	-0.185	-0.015	-0.644*	-0.106	0.107	-0.106	-0.483	-0.109
	(0.541)	(0.292)	(0.088)	(0.348)	(0.172)	(0.375)	(0.092)	(0.355)	(0.089)
One product	0.054	0.385	0.073	0.175	0.142	0.237	0.074	-0.020	0.029
	(0.712)	(0.340)	(0.091)	(0.310)	(0.195)	(0.494)	(0.104)	(0.334)	(0.101)
All products × X	0.033	0.021	-0.163	0.113*	0.009	-0.005	0.017	0.436	0.002
	(0.044)	(0.058)	(0.188)	(0.062)	(0.061)	(0.009)	(0.030)	(0.343)	(0.003)
One product × X	0.000	-0.071	-0.037	-0.026	-0.037	-0.004	-0.017	0.085	0.003
	(0.057)	(0.069)	(0.200)	(0.059)	(0.082)	(0.012)	(0.034)	(0.361)	(0.004)
R-squared	0.114	0.116	0.115	0.119	0.114	0.114	0.115	0.117	0.115
No. of obs.	846	846	846	846	846	846	846	846	846
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.7: Impacts on children's educational achievement - English: heterogeneity (OLS)

Dependent variable:	English: GPA z-scores								
X:	Age	Education	Male	Household size	No. of male members	Head age	Head education	Head male	Land size
	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)	(1g)	(1h)	(1i)
December in 2013									
All products	-1.398**	-0.320	-0.076	0.118	0.145	0.437	-0.072	-0.019	-0.070
	(0.580)	(0.245)	(0.075)	(0.243)	(0.151)	(0.340)	(0.065)	(0.215)	(0.064)
One product	-0.923	-0.322	-0.099	0.197	0.059	-0.105	-0.132*	-0.327	-0.099
	(0.564)	(0.228)	(0.097)	(0.337)	(0.160)	(0.330)	(0.076)	(0.223)	(0.074)
All products × X	0.109**	0.058	0.051	-0.035	-0.083	-0.012	0.013	-0.040	0.001
	(0.045)	(0.047)	(0.157)	(0.044)	(0.062)	(0.008)	(0.031)	(0.231)	(0.002)
One product × X	0.064	0.041	-0.088	-0.069	-0.082	-0.001	-0.004	0.208	-0.003
	(0.047)	(0.053)	(0.142)	(0.069)	(0.066)	(0.008)	(0.035)	(0.241)	(0.005)
R-squared	0.258	0.254	0.254	0.254	0.255	0.255	0.254	0.254	0.255
No. of obs.	850	850	850	850	850	850	850	850	850
	(2a)	(2b)	(2c)	(2d)	(2e)	(2f)	(2g)	(2h)	(2i)
December in 2014									
All products	-0.327	0.099	0.014	-0.424	0.015	-0.099	-0.079	-0.344	-0.044
	(0.563)	(0.294)	(0.081)	(0.366)	(0.197)	(0.311)	(0.094)	(0.352)	(0.089)
One product	0.557	0.398	0.034	0.070	0.183	0.255	0.026	-0.244	0.056
	(0.646)	(0.274)	(0.104)	(0.331)	(0.175)	(0.377)	(0.091)	(0.279)	(0.100)
All products × X	0.024	-0.030	-0.115	0.078	-0.020	0.002	0.035	0.339	0.001
	(0.045)	(0.062)	(0.178)	(0.065)	(0.069)	(0.007)	(0.034)	(0.340)	(0.002)
One product × X	-0.041	-0.078	0.022	-0.006	-0.060	-0.005	0.010	0.313	-0.001
	(0.050)	(0.055)	(0.169)	(0.068)	(0.072)	(0.009)	(0.036)	(0.280)	(0.004)
R-squared	0.100	0.100	0.099	0.101	0.099	0.099	0.100	0.101	0.099
No. of obs.	846	846	846	846	846	846	846	846	846
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.8: Impacts on children's educational achievement - Math: heterogeneity (OLS)

Dependent variable:	Math: GPA z-scores								
X:	Age	Education	Male	Household size	No. of male members	Head age	Head education	Head male	Land size
	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)	(1g)	(1h)	(1i)
December in 2013									
All products	-0.981*	-0.126	-0.130	0.297	0.105	0.233	-0.030	0.055	-0.034
	(0.556)	(0.198)	(0.084)	(0.222)	(0.144)	(0.370)	(0.062)	(0.222)	(0.066)
One product	-0.048	0.103	-0.063	-0.055	-0.026	-0.302	-0.050	-0.114	-0.026
	(0.657)	(0.243)	(0.090)	(0.316)	(0.165)	(0.349)	(0.077)	(0.239)	(0.067)
All products × X	0.076*	0.018	0.212*	-0.068	-0.060	-0.007	-0.008	-0.105	-0.001
	(0.045)	(0.041)	(0.121)	(0.044)	(0.051)	(0.008)	(0.028)	(0.227)	(0.001)
One product × X	-0.003	-0.041	-0.060	-0.006	-0.025	0.005	-0.030	0.029	-0.006
	(0.053)	(0.051)	(0.133)	(0.064)	(0.067)	(0.008)	(0.028)	(0.263)	(0.004)
R-squared	0.392	0.390	0.391	0.390	0.390	0.390	0.390	0.389	0.391
No. of obs.	850	850	850	850	850	850	850	850	850
	(2a)	(2b)	(2c)	(2d)	(2e)	(2f)	(2g)	(2h)	(2i)
December in 2014									
All products	-0.633	-0.108	0.028	-0.697*	-0.083	-0.092	-0.138	-0.429	-0.132
	(0.532)	(0.255)	(0.090)	(0.385)	(0.171)	(0.406)	(0.104)	(0.316)	(0.097)
One product	0.089	0.435	-0.023	-0.076	0.047	-0.362	0.054	-0.275	0.023
	(0.675)	(0.292)	(0.093)	(0.368)	(0.226)	(0.522)	(0.095)	(0.358)	(0.097)
All products × X	0.043	0.001	-0.308*	0.120*	-0.008	-0.000	0.030	0.361	0.003
	(0.041)	(0.047)	(0.156)	(0.067)	(0.056)	(0.010)	(0.031)	(0.320)	(0.002)
One product × X	-0.004	-0.086	0.152	0.023	-0.003	0.010	-0.016	0.343	0.002
	(0.053)	(0.058)	(0.186)	(0.074)	(0.096)	(0.012)	(0.030)	(0.367)	(0.004)
R-squared	0.162	0.164	0.168	0.166	0.162	0.163	0.163	0.164	0.163
No. of obs.	846	846	846	846	846	846	846	846	846
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.9: Impacts on children's educational achievement - General science: heterogeneity (OLS)

Dependent variable:	General science: GPA z-scores								
X:	Age	Education	Male	Household size	No. of male members	Head age	Head education	Head male	Land size
	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)	(1g)	(1h)	(1i)
December in 2013									
All products	-0.428	0.156	-0.009	0.234	0.206	0.383	0.067	0.068	0.029
	(0.675)	(0.305)	(0.095)	(0.263)	(0.172)	(0.414)	(0.086)	(0.224)	(0.084)
One product	0.675	0.259	0.017	0.003	0.007	-0.049	0.025	0.056	0.029
	(0.675)	(0.283)	(0.091)	(0.296)	(0.161)	(0.363)	(0.075)	(0.204)	(0.083)
All products × X	0.039	-0.023	0.144	-0.037	-0.064	-0.008	-0.012	-0.018	0.002
	(0.052)	(0.058)	(0.126)	(0.048)	(0.056)	(0.010)	(0.034)	(0.234)	(0.002)
One product × X	-0.051	-0.048	0.042	0.007	0.014	0.002	0.011	-0.021	0.001
	(0.053)	(0.055)	(0.151)	(0.057)	(0.063)	(0.008)	(0.035)	(0.206)	(0.003)
R-squared	0.299	0.298	0.298	0.298	0.298	0.298	0.297	0.297	0.298
No. of obs.	850	850	850	850	850	850	850	850	850
	(2a)	(2b)	(2c)	(2d)	(2e)	(2f)	(2g)	(2h)	(2i)
December in 2014									
All products	-1.166**	-0.303	-0.041	-0.558	-0.080	0.318	-0.132	-0.411	-0.115
	(0.455)	(0.259)	(0.096)	(0.353)	(0.178)	(0.309)	(0.093)	(0.323)	(0.085)
One product	-0.566	0.083	-0.077	-0.084	-0.035	0.076	-0.077	-0.458*	-0.059
	(0.671)	(0.305)	(0.116)	(0.346)	(0.207)	(0.463)	(0.112)	(0.254)	(0.104)
All products × X	0.086**	0.044	-0.143	0.092	-0.009	-0.010	0.023	0.341	0.001
	(0.039)	(0.056)	(0.173)	(0.066)	(0.068)	(0.007)	(0.033)	(0.313)	(0.002)
One product × X	0.041	-0.031	0.037	0.004	-0.012	-0.003	0.010	0.432	-0.000
	(0.053)	(0.059)	(0.175)	(0.069)	(0.085)	(0.011)	(0.035)	(0.280)	(0.003)
R-squared	0.151	0.150	0.149	0.151	0.148	0.149	0.149	0.151	0.148
No. of obs.	846	846	846	846	846	846	846	846	846
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.10: Impacts on children's educational achievement - Islam studies: heterogeneity (OLS)

Dependent variable:	Islam studies: GPA z-scores								
X:	Age	Education	Male	Household size	No. of male members	Head age	Head education	Head male	Land size
	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)	(1g)	(1h)	(1i)
December in 2013									
All products	0.093	0.234	-0.048	0.304	0.181	0.358	0.038	0.288	0.062
	(0.699)	(0.290)	(0.112)	(0.280)	(0.177)	(0.402)	(0.088)	(0.237)	(0.087)
One product	0.888	0.560*	-0.072	0.144	-0.020	-0.295	-0.004	0.265	0.076
	(0.667)	(0.279)	(0.098)	(0.347)	(0.171)	(0.397)	(0.082)	(0.203)	(0.077)
All products × X	-0.003	-0.040	0.239	-0.050	-0.052	-0.007	0.013	-0.256	-0.001
	(0.055)	(0.057)	(0.156)	(0.050)	(0.063)	(0.009)	(0.028)	(0.242)	(0.001)
One product × X	-0.070	-0.118*	0.209	-0.025	0.018	0.008	0.019	-0.268	-0.005
	(0.054)	(0.062)	(0.140)	(0.071)	(0.072)	(0.009)	(0.039)	(0.200)	(0.003)
R-squared	0.259	0.261	0.260	0.258	0.258	0.259	0.258	0.258	0.259
No. of obs.	850	850	850	850	850	850	850	850	850
	(2a)	(2b)	(2c)	(2d)	(2e)	(2f)	(2g)	(2h)	(2i)
December in 2014									
All products	-0.928*	-0.225	0.059	-0.568	0.040	0.380	-0.085	-0.387	-0.085
	(0.527)	(0.274)	(0.095)	(0.355)	(0.172)	(0.326)	(0.105)	(0.280)	(0.097)
One product	0.353	0.309	0.041	0.236	0.101	0.329	0.033	-0.340	0.013
	(0.611)	(0.307)	(0.117)	(0.337)	(0.200)	(0.469)	(0.115)	(0.345)	(0.116)
All products × X	0.070	0.036	-0.278	0.103	-0.041	-0.011	0.020	0.361	0.003
	(0.043)	(0.054)	(0.169)	(0.065)	(0.062)	(0.008)	(0.029)	(0.280)	(0.003)
One product × X	-0.025	-0.058	0.006	-0.041	-0.025	-0.007	0.005	0.416	0.003
	(0.048)	(0.060)	(0.195)	(0.065)	(0.081)	(0.011)	(0.034)	(0.371)	(0.005)
R-squared	0.110	0.109	0.111	0.112	0.108	0.109	0.108	0.110	0.108
No. of obs.	846	846	846	846	846	846	846	846	846
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.11: Impacts on children's educational achievement - Bangladesh general studies: heterogeneity (OLS)

Dependent variable:	Bangladesh general studies: GPA z-scores								
X:	Age	Education	Male	Household size	No. of male members	Head age	Head education	Head male	Land size
	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)	(1g)	(1h)	(1i)
December in 2013									
All products	-0.337	0.082	-0.021	0.236	0.131	0.272	0.085	0.089	0.055
	(0.519)	(0.220)	(0.072)	(0.258)	(0.153)	(0.405)	(0.078)	(0.195)	(0.072)
One product	0.531	0.438	0.048	0.259	-0.017	-0.145	0.117	-0.038	0.118
	(0.686)	(0.338)	(0.099)	(0.330)	(0.163)	(0.341)	(0.084)	(0.229)	(0.099)
All products × X	0.033	-0.004	0.202	-0.034	-0.027	-0.005	-0.015	-0.025	0.001
	(0.041)	(0.042)	(0.134)	(0.050)	(0.059)	(0.010)	(0.030)	(0.209)	(0.002)
One product × X	-0.033	-0.069	0.167	-0.028	0.060	0.006	0.005	0.173	0.000
	(0.055)	(0.069)	(0.146)	(0.062)	(0.061)	(0.008)	(0.038)	(0.237)	(0.003)
R-squared	0.271	0.271	0.272	0.270	0.271	0.271	0.270	0.270	0.270
No. of obs.	850	850	850	850	850	850	850	850	850
	(2a)	(2b)	(2c)	(2d)	(2e)	(2f)	(2g)	(2h)	(2i)
December in 2014									
All products	-0.864	-0.324	-0.020	-0.287	0.033	0.125	-0.155	-0.355	-0.144
	(0.647)	(0.306)	(0.103)	(0.309)	(0.190)	(0.338)	(0.104)	(0.283)	(0.096)
One product	0.179	0.365	-0.020	0.457	0.183	0.480	-0.008	0.046	-0.017
	(0.730)	(0.329)	(0.115)	(0.330)	(0.176)	(0.480)	(0.099)	(0.381)	(0.100)
All products × X	0.060	0.042	-0.251	0.032	-0.065	-0.006	0.023	0.250	0.002
	(0.051)	(0.060)	(0.162)	(0.053)	(0.065)	(0.008)	(0.030)	(0.270)	(0.003)
One product × X	-0.016	-0.084	0.001	-0.100	-0.087	-0.012	-0.013	-0.073	-0.000
	(0.057)	(0.067)	(0.206)	(0.065)	(0.076)	(0.011)	(0.029)	(0.395)	(0.003)
R-squared	0.129	0.131	0.130	0.130	0.129	0.128	0.128	0.128	0.128
No. of obs.	846	846	846	846	846	846	846	846	846
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.12: Impacts on households' willingness to buy solar products (OLS)

Dependent variable:	One if willing to buy			
	any solar products	S2	S10	S250
Sample:	All	Those that were willing to buy		
	(a)	(b)	(c)	(d)
With no HH baseline control				
All products	0.416***	0.198***	0.148**	0.094**
	(0.062)	(0.062)	(0.060)	(0.044)
One product	0.361***	0.043	0.038	0.090*
	(0.065)	(0.061)	(0.061)	(0.047)
All = one (p-values)	0.170	0.014	0.047	0.793
All + one = 0 (p-values)	0.000	0.031	0.096	0.048
R-squared	0.246	0.187	0.177	0.087
No. of obs.	847	492	492	492
	(e)	(f)	(g)	(i)
With HH baseline control				
All products	0.420***	0.199***	0.146**	0.093**
	(0.061)	(0.064)	(0.058)	(0.045)
One product	0.365***	0.049	0.041	0.091*
	(0.063)	(0.061)	(0.060)	(0.046)
All = one (p-values)	0.180	0.011	0.044	0.886
All + one = 0 (p-values)	0.000	0.032	0.088	0.048
R-squared	0.255	0.197	0.189	0.094
No. of obs.	847	492	492	492
Village FE	Yes	Yes	Yes	Yes
Mean y (control)	0.378	0.094	0.113	0.886

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each village. (3) The baseline controls include household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.13: Impacts on children's time use: other activities (OLS)

Dependent var.	Per-day minutes (average from Sep 2013 to Apr 2014) spent on:			
	Sports	Cooking and bath	Household chores	Other
	(a)	(b)	(c)	(d)
With no baseline controls				
All products	-0.811	0.130	3.821	-7.672
	(2.196)	(1.843)	(4.686)	(11.285)
One product	0.958	-2.127	7.523	-11.918
	(2.636)	(2.005)	(5.449)	(12.838)
All = one (p-val.)	0.558	0.311	0.316	0.665
All + one = 0 (p-val.)	0.969	0.531	0.239	0.381
R-squared	0.213	0.228	0.159	0.391
No. of obs.	620	620	620	620
	(e)	(f)	(g)	(h)
With baseline controls				
All products	0.108	-0.945	3.589	-7.719
	(2.297)	(1.899)	(4.670)	(10.812)
One product	1.474	-2.325	7.516	-14.044
	(2.590)	(1.945)	(5.342)	(12.483)
All = one (p-val.)	0.655	0.544	0.315	0.574
All + one = 0 (p-val.)	0.682	0.299	0.237	0.295
R-squared	0.250	0.284	0.173	0.402
No. of obs.	620	620	620	620
School FE	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes
Mean y (control)	67.28	71.10	123.75	585.46

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.14: Information on lighting sources at follow-up

Panel A: No. of light sources (852 households)

	Treatment A		Treatment B		Control	
	Mean	Std.	Mean	Std.	Mean	Std.
Flashlight	0.04	0.20	0.10	0.31	0.12	0.33
Kerosene lanterns	0.02	0.15	0.07	0.30	0.27	0.48
Kerosene lamps	0.31	0.61	1.14	0.61	1.66	0.83

Panel B: Per-day hours using light sources based on family questionnaires, not a time diary (852 households)

	Treatment A		Treatment B		Control	
	Mean	Std.	Mean	Std.	Mean	Std.
Flashlight (rainy)	0.09	0.52	0.25	0.77	0.31	0.90
Flashlight (off-rainy)	0.13	0.68	0.41	1.24	0.46	1.28
Kerosene lanterns (rainy)	0.06	0.42	0.21	0.91	0.76	1.39
Kerosene lanterns (off-rainy)	0.07	0.46	0.25	1.05	0.97	1.73
Kerosene lamps (rainy)	0.58	1.22	2.75	1.97	4.26	2.03
Kerosene lamps (off-rainy)	0.77	1.69	3.57	2.48	5.19	2.41
S2 (rainy)	2.12	0.85	-	-	-	-
S2 (off-rainy)	2.76	0.84	-	-	-	-
S10 (rainy)	2.30	0.81	-	-	-	-
S10 (off-rainy)	2.92	0.74	-	-	-	-
S250 (rainy)	2.38	0.87	2.86	0.85	-	-
S250 (off-rainy)	3.09	0.82	3.17	0.69	-	-

Panel C: Expenditures (in Bangladesh Taka, BDT)

	Treatment A		Treatment B		Control	
	Mean	Std.	Mean	Std.	Mean	Std.
Food (12 mth)	61558.06	20218.79	61218.47	18070.34	63414.54	19610.40
School fees (6 mth)	3196.00	1901.03	3196.26	2035.94	3105.54	1859.43
Medical fees (12 mth)	1891.12	1589.65	2045.54	2040.55	2265.76	4747.81
Kerosene (12 mth)	134.65	358.85	787.61	587.00	1542.79	912.75
Other non-food (12 mth)	10537.33	3420.76	10757.64	2847.53	10755.38	3285.35

Panel D: Major activities by light sources

	Treatment A			Treatment B			Control		
	Flashlight	Kerosene lanterns	Kerosene lamps	Flashlight	Kerosene lanterns	Kerosene lamps	Flashlight	Kerosene lanterns	Kerosene lamps
Reading/studying	0.10	0.50	0.54	-	0.84	0.48	0.14	0.97	0.89
Social interaction	-	0.16	0.06	0.19	0.07	0.17	0.32	0.08	0.17
Cooking/eating at night	-	0.16	0.68	-	0.61	0.84	0.06	0.43	0.94
Walking outside at night	0.90	0.66	0.40	0.85	0.38	0.58	0.84	0.33	0.71
Tending livestock	-	0.16	0.06	0.14	0.15	0.19	0.06	0.07	0.23
Income generating activities	-	-	-	-	-	0.00	0.02	0.00	0.02
Nightlight for security	0.80	0.33	0.37	0.71	0.15	0.26	0.58	0.17	0.34
No. of households	10	6	61	21	13	168	50	110	401
	S2	S10	S250	S2	S10	S250	S2	S10	S250
Reading/studying	0.28	0.07	0.73	-	-	1.00	-	-	-
Social interaction	0.65	0.25	0.18	-	-	0.11	-	-	-
Cooking/eating at night	0.73	0.23	0.50	-	-	0.88	-	-	-
Walking outside at night	0.23	0.66	0.06	-	-	-	-	-	-
Tending livestock	0.06	0.49	0.16	-	-	-	-	-	-
Income generating activities	0.00	0.20	0.19	-	-	-	-	-	-
Nightlight for security	-	0.02	0.10	-	-	-	-	-	-
Recharge cell phone	-	-	0.05	-	-	-	-	-	-
No. of households	238	239	239	-	-	188	-	-	-

Table S.15: Cost-effectiveness of solar lanterns on school attendance

	Percentage point gain of attendance rate	Additional years of attendance per 100 USD spent		
		Point estimate	Lower bound (90% CI)	Upper bound (90% CI)
With no baseline controls				
All products	0.084	0.669	0.341	0.996
One product	0.045	0.568	0.070	1.067
Overall	-	0.635	0.25	1.020
With baseline controls				
All products	0.077	0.613	0.286	0.94
One product	0.044	0.556	0.057	1.054
Overall	-	0.594	0.209	0.979

Notes: (1) The treatment effects exploited for the cost-effectiveness calculation are based on those shown in columns (d) and (h) in Table 6. (2) The CI stands for "confidence intervals."

Table S.16: Impacts on children's educational inputs: heterogeneity (OLS)

Dependent variable:	Total home study time (per-day minutes, average from Sep 2013 to Apr 2014)								
X:	Age	Education	Male	Household size	No. of male members	Head age	Head education	Head male	Land size
	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)	(1g)	(1h)	(1i)
December in 2013									
All products	-5.511	8.793	22.219***	1.224	22.584*	25.447	14.036***	30.195**	11.254*
	(41.480)	(20.413)	(6.961)	(16.061)	(11.185)	(28.555)	(5.110)	(14.767)	(5.817)
One product	-46.114	-3.671	26.576***	18.592	40.162***	20.608	18.024***	36.200	15.769***
	(40.258)	(18.197)	(8.309)	(20.161)	(13.474)	(23.372)	(5.430)	(26.672)	(5.798)
All products × X	1.510	0.974	-21.588**	2.338	-3.862	-0.298	-0.938	-18.917	0.190
	(3.203)	(3.970)	(9.060)	(2.872)	(3.422)	(0.646)	(1.809)	(15.171)	(0.189)
One product × X	5.339	5.142	-16.497	0.049	-9.128*	-0.037	0.929	-18.836	0.332
	(3.350)	(4.057)	(10.597)	(4.313)	(5.122)	(0.545)	(1.577)	(26.654)	(0.232)
R-squared	0.177	0.176	0.181	0.174	0.178	0.174	0.174	0.176	0.176
No. of obs.	620	620	620	620	620	620	620	620	620
Dependent variable:	One if attend in Feb 2014								
	(2a)	(2b)	(2c)	(2d)	(2e)	(2f)	(2g)	(2h)	(2i)
All products	-0.378	-0.126	0.079*	-0.052	-0.035	0.066	0.083*	0.175	0.131***
	(0.270)	(0.108)	(0.046)	(0.132)	(0.102)	(0.220)	(0.048)	(0.119)	(0.042)
One product	-0.417	-0.068	0.039	-0.030	-0.027	-0.169	0.040	0.113	0.070*
	(0.276)	(0.118)	(0.052)	(0.153)	(0.080)	(0.200)	(0.044)	(0.144)	(0.039)
All products × X	0.039*	0.051**	0.065	0.032	0.058	0.001	0.018	-0.075	-0.003**
	(0.022)	(0.022)	(0.088)	(0.025)	(0.041)	(0.005)	(0.014)	(0.128)	(0.001)
One product × X	0.038	0.026	0.020	0.016	0.031	0.005	0.005	-0.070	-0.002
	(0.023)	(0.026)	(0.082)	(0.031)	(0.029)	(0.005)	(0.017)	(0.150)	(0.001)
R-squared	0.239	0.239	0.236	0.237	0.239	0.236	0.237	0.236	0.239
No. of obs.	850	850	850	850	850	850	850	850	850
Dependent variable:	One if attend in April 2014								
	(3a)	(3b)	(3c)	(3d)	(3e)	(3f)	(3g)	(3h)	(3i)
All products	-0.203	0.132	0.120**	0.201*	0.154*	0.190	0.114***	0.108	0.112**
	(0.358)	(0.126)	(0.049)	(0.107)	(0.077)	(0.218)	(0.037)	(0.125)	(0.042)
One product	0.257	0.228	0.108**	0.237	0.144	0.218	0.109**	0.212	0.092*
	(0.327)	(0.147)	(0.051)	(0.175)	(0.090)	(0.188)	(0.050)	(0.174)	(0.051)
All products × X	0.024	-0.009	-0.067	-0.022	-0.026	-0.002	-0.017*	-0.019	-0.002
	(0.029)	(0.028)	(0.085)	(0.019)	(0.027)	(0.005)	(0.009)	(0.122)	(0.002)
One product × X	-0.013	-0.030	-0.043	-0.031	-0.023	-0.003	-0.015	-0.135	-0.000
	(0.028)	(0.035)	(0.091)	(0.037)	(0.042)	(0.004)	(0.014)	(0.179)	(0.002)
R-squared	0.232	0.231	0.231	0.231	0.231	0.230	0.232	0.231	0.232
No. of obs.	850	850	850	850	850	850	850	850	850
Dependent variable:	One if attend in August 2014								
	(4a)	(4b)	(4c)	(4d)	(4e)	(4f)	(4g)	(4h)	(4i)
All products	0.124	-0.120	0.014	-0.235	-0.013	0.213	0.022	-0.123	0.037
	(0.195)	(0.083)	(0.037)	(0.151)	(0.096)	(0.136)	(0.037)	(0.124)	(0.033)
One product	0.132	-0.066	-0.022	0.240	0.058	0.065	-0.009	-0.083	-0.005
	(0.211)	(0.095)	(0.042)	(0.152)	(0.103)	(0.183)	(0.036)	(0.139)	(0.041)
All products × X	-0.008	0.031*	0.017	0.052*	0.015	-0.005	0.000	0.160	-0.001
	(0.016)	(0.016)	(0.064)	(0.030)	(0.036)	(0.003)	(0.014)	(0.134)	(0.001)
One product × X	-0.011	0.014	0.047	-0.051	-0.026	-0.002	0.006	0.090	0.000
	(0.017)	(0.018)	(0.067)	(0.030)	(0.042)	(0.004)	(0.010)	(0.141)	(0.002)
R-squared	0.262	0.263	0.262	0.270	0.263	0.263	0.262	0.263	0.263
No. of obs.	850	850	850	850	850	850	850	850	850
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.17: Children's educational efficiency - GPA z-scores: specification (1) (OLS)

Dependent variables:	Bengali	English	Math	General science	Islam studies	Bangladesh general studies
	(a)	(b)	(c)	(d)	(e)	(f)
Study at school	-0.001	-0.000	-0.002	0.001	-0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Study at school (per-day minutes)	0.001	0.001	0.001	0.002	-0.001	0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Study at home (day, per-day minutes)	-0.002	-0.001	0.000	-0.002	-0.001	-0.002
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
Study at home (night, per-day minutes)	0.215**	0.134	0.150	0.182**	0.213**	0.197*
	(0.101)	(0.092)	(0.101)	(0.085)	(0.099)	(0.115)
One if attend (February)	0.215**	0.134	0.150	0.182**	0.213**	0.197*
	(0.101)	(0.092)	(0.101)	(0.085)	(0.099)	(0.115)
One if attend (April)	-0.245***	-0.206*	-0.148	-0.205**	-0.207**	-0.129
	(0.090)	(0.102)	(0.093)	(0.089)	(0.077)	(0.125)
One if attend (August)	0.039	-0.001	0.044	0.086	-0.006	-0.030
	(0.074)	(0.096)	(0.070)	(0.079)	(0.088)	(0.097)
R-squared	0.135	0.130	0.175	0.166	0.131	0.139
No. of obs.	618	618	618	618	618	618
Baseline control	No	No	No	No	No	No
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade.

Table S.18: Children's educational efficiency - GPA z-scores: specification (2) (OLS)

Dependent variables:	Bengali	English	Math	General science	Islam studies	Bangladesh general studies
	(a)	(b)	(c)	(d)	(e)	(f)
All products	0.028	0.018	-0.085	-0.058	-0.001	-0.085
	(0.111)	(0.099)	(0.095)	(0.100)	(0.104)	(0.115)
One product	0.181	0.090	0.069	-0.052	0.121	0.025
	(0.118)	(0.107)	(0.108)	(0.107)	(0.113)	(0.121)
Study at school	-0.001	-0.000	-0.002	0.000	-0.000	-0.001
(per-day minutes)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Study at home	0.001	0.001	0.000	0.001	-0.000	-0.000
(day, per-day minutes)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Study at home	-0.002	-0.001	0.000	-0.002	-0.001	-0.002
(night, per-day minutes)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
One if attend	0.213**	0.133	0.158	0.187**	0.214**	0.205*
(February)	(0.100)	(0.092)	(0.099)	(0.085)	(0.099)	(0.114)
One if attend	-0.254***	-0.211**	-0.149	-0.201**	-0.213***	-0.127
(April)	(0.092)	(0.104)	(0.093)	(0.088)	(0.078)	(0.125)
One if attend	0.043	0.001	0.047	0.085	-0.003	-0.029
(August)	(0.076)	(0.097)	(0.069)	(0.078)	(0.090)	(0.098)
R-squared	0.140	0.131	0.178	0.167	0.133	0.141
No. of obs.	618	618	618	618	618	618
Baseline control	No	No	No	No	No	No
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade.

Table S.19: Children's educational efficiency - GPA z-scores: specification (3) (OLS)

Dependent variables:	Bengali	English	Math	General science	Islam studies	Bangladesh general studies
	(a)	(b)	(c)	(d)	(e)	(f)
All products	-2.285***	-1.545**	-2.363***	-2.445***	-1.832***	-1.635***
	(0.747)	(0.637)	(0.582)	(0.665)	(0.643)	(0.566)
One product	-0.511	0.248	0.108	-0.605	0.066	-0.152
	(0.742)	(0.620)	(0.788)	(0.655)	(0.810)	(0.694)
Study at school	-0.003*	-0.002	-0.004**	-0.001	-0.001	-0.003*
(per-day minutes)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)
Study at home	-0.001	-0.001	0.000	-0.002	-0.003	-0.002
(day, per-day minutes)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Study at home	-0.001	0.002	0.001	-0.001	-0.000	0.001
(night, per-day minutes)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
One if attend	0.125	0.032	0.021	0.131	0.187	0.179
(February)	(0.127)	(0.134)	(0.144)	(0.116)	(0.126)	(0.136)
One if attend	-0.242*	-0.237**	-0.194	-0.175	-0.203	-0.100
(April)	(0.120)	(0.112)	(0.123)	(0.119)	(0.127)	(0.134)
One if attend	-0.142	-0.269*	-0.023	-0.148	-0.163	-0.276**
(August)	(0.108)	(0.137)	(0.105)	(0.120)	(0.118)	(0.136)
All products						
× Study at	0.008**	0.005*	0.008***	0.007***	0.005	0.008***
school	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)
× Study at	0.009**	0.007	0.006	0.011***	0.009**	0.004
home (day)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
× Study at	-0.003	-0.005	-0.001	-0.003	-0.002	-0.004
home (night)	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)
× One if attend	0.372*	0.308	0.459**	0.282	0.175	0.212
(February)	(0.206)	(0.215)	(0.219)	(0.185)	(0.193)	(0.202)
× One if attend	-0.168	-0.069	-0.008	-0.103	-0.108	-0.239
(April)	(0.195)	(0.221)	(0.205)	(0.181)	(0.180)	(0.183)
× One if attend	0.120	0.516**	-0.084	0.242	0.129	0.157
(August)	(0.186)	(0.215)	(0.157)	(0.223)	(0.196)	(0.201)
One product						
× Study at	0.001	-0.000	0.001	-0.001	-0.001	0.000
school	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)
× Study at	-0.000	-0.002	-0.009*	0.000	-0.003	-0.001
home (day)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)
× Study at	-0.000	-0.004	0.001	0.001	0.000	-0.004
home (night)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
× One if attend	0.222	0.288	0.425*	0.190	0.147	0.130
(February)	(0.202)	(0.242)	(0.215)	(0.234)	(0.220)	(0.220)
× One if attend	0.085	0.110	0.120	-0.067	0.020	0.052
(April)	(0.274)	(0.251)	(0.255)	(0.239)	(0.268)	(0.246)
× One if attend	0.506***	0.358*	0.307	0.544***	0.409*	0.724***
(August)	(0.179)	(0.178)	(0.201)	(0.197)	(0.211)	(0.212)
R-squared	0.180	0.164	0.225	0.209	0.163	0.181
No. of obs.	618	618	618	618	618	618
Baseline control	No	No	No	No	No	No
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade.

Table S.20: Impacts on children's educational achievement: complementarity (OLS)

Dependent variable:	One if pass					
X:	No. of students in each school-grade	School-level ratio of				
		no. of teachers to no. of students	no. of blackboards to no. of students	no. of benches to no. of students	no. of fans to no. of students	no. of toilets to no. of students
	(a)	(b)	(c)	(d)	(e)	(f)
December in 2013						
All products	-0.083	-0.072	0.099	0.018	0.008	0.017
	(0.067)	(0.124)	(0.105)	(0.107)	(0.032)	(0.053)
One product	0.090	-0.002	0.056	0.038	-0.004	-0.023
	(0.066)	(0.087)	(0.064)	(0.092)	(0.027)	(0.054)
All products × X	0.002*	3.935	-4.001	0.011	3.444**	1.474
	(0.001)	(4.898)	(4.548)	(0.211)	(1.524)	(11.093)
One product × X	-0.002	-0.045	-3.125	-0.094	0.414	5.329
	(0.002)	(4.323)	(3.745)	(0.192)	(3.675)	(9.225)
No. of students in each school-grade	-0.004*	-	-	-	-	-
	(0.002)					
R-squared	0.333	0.325	0.325	0.325	0.326	0.325
No. of obs.	849	850	850	850	850	850
	(g)	(h)	(i)	(j)	(k)	(l)
December in 2014						
All products	-0.216**	-0.106	-0.015	-0.025	-0.057	-0.026
	(0.088)	(0.160)	(0.122)	(0.125)	(0.047)	(0.080)
One product	-0.137	-0.106	0.120	0.208	-0.020	-0.048
	(0.110)	(0.160)	(0.120)	(0.170)	(0.041)	(0.058)
All products × X	0.003**	2.023	-2.258	-0.075	-0.217	-8.498
	(0.001)	(6.993)	(6.497)	(0.242)	(1.652)	(14.958)
One product × X	0.002	3.410	-7.558	-0.527	-0.895	6.572
	(0.002)	(5.996)	(6.081)	(0.369)	(2.894)	(14.453)
No. of students in each school-grade	-0.001	-	-	-	-	-
	(0.002)					
R-squared	0.151	0.146	0.147	0.148	0.145	0.146
No. of obs.	844	845	845	845	845	845
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes
Mean of X	50.26	0.02	0.01	0.43	0.00	0.00
Std. of X	20.97	0.00	0.00	0.12	0.01	0.00

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number). (4) The reported mean and standard deviation were estimated at the level of the sample respondents.

Table S.21: Impacts on children's educational achievement - Bengali: complementarity (OLS)

Dependent variable:	Bengali: GPA z-scores					
X:	No. of students in each school-grade	School-level ratio of				
		no. of teachers to no. of students	no. of blackboards to no. of students	no. of benches to no. of students	no. of fans to no. of students	no. of toilets to no. of students
	(a)	(b)	(c)	(d)	(e)	(f)
December in 2013						
All products	-0.019	-0.609**	-0.366	-0.406	-0.077	-0.087
	(0.198)	(0.248)	(0.383)	(0.299)	(0.089)	(0.105)
One product	0.472**	-0.314	-0.069	0.430	0.046	-0.098
	(0.175)	(0.323)	(0.294)	(0.268)	(0.082)	(0.126)
All products × X	-0.001	23.416**	16.736	0.819	7.229*	10.307
	(0.003)	(10.051)	(17.402)	(0.606)	(4.210)	(24.454)
One product × X	-0.009***	14.169	4.937	-0.922	-4.466	32.113
	(0.003)	(14.041)	(14.672)	(0.612)	(10.172)	(26.922)
No. of students in each school-grade	-0.008	-	-	-	-	-
	(0.005)					
R-squared	0.268	0.261	0.259	0.263	0.260	0.258
No. of obs.	849	850	850	850	850	850
	(g)	(h)	(i)	(j)	(k)	(l)
December in 2014						
All products	-0.318*	0.485	0.015	-0.403	-0.052	-0.185
	(0.181)	(0.294)	(0.211)	(0.245)	(0.087)	(0.136)
One product	-0.181	0.554	0.166	-0.120	0.089	-0.147
	(0.254)	(0.377)	(0.267)	(0.365)	(0.092)	(0.153)
All products × X	0.005*	-23.724*	-5.259	0.725	-7.669	25.971
	(0.003)	(11.772)	(11.933)	(0.577)	(6.253)	(26.620)
One product × X	0.005	-20.832	-5.769	0.402	-7.942	53.571
	(0.004)	(14.643)	(15.206)	(0.843)	(10.880)	(32.760)
No. of students in each school-grade	0.002	-	-	-	-	-
	(0.003)					
R-squared	0.117	0.119	0.114	0.115	0.116	0.118
No. of obs.	845	846	846	846	846	846
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.22: Impacts on children's educational achievement - English: complementarity (OLS)

Dependent variable:	English: GPA z-scores					
X:	No. of students in each school-grade	School-level ratio of				
		no. of teachers to no. of students	no. of blackboards to no. of students	no. of benches to no. of students	no. of fans to no. of students	no. of toilets to no. of students
	(a)	(b)	(c)	(d)	(e)	(f)
December in 2013						
All products	-0.150	-0.652***	-0.153	-0.316	-0.078	0.053
	(0.160)	(0.203)	(0.281)	(0.241)	(0.067)	(0.080)
One product	0.144	-0.355	0.039	0.194	-0.127*	-0.140
	(0.161)	(0.244)	(0.169)	(0.231)	(0.067)	(0.120)
All products × X	0.002	24.763***	5.024	0.593	5.228	-28.966
	(0.002)	(7.792)	(12.761)	(0.491)	(3.273)	(18.708)
One product × X	-0.005*	9.281	-9.090	-0.748	-1.410	1.732
	(0.003)	(10.820)	(9.168)	(0.512)	(8.282)	(21.644)
No. of students in each school-grade	-0.003	-	-	-	-	-
	(0.006)					
R-squared	0.257	0.258	0.254	0.257	0.254	0.255
No. of obs.	849	850	850	850	850	850
	(g)	(h)	(i)	(j)	(k)	(l)
December in 2014						
All products	-0.325*	0.249	-0.088	-0.329	-0.006	-0.040
	(0.186)	(0.303)	(0.201)	(0.252)	(0.096)	(0.158)
One product	-0.348	0.587*	0.274	-0.129	0.063	-0.171
	(0.257)	(0.330)	(0.328)	(0.361)	(0.093)	(0.148)
All products × X	0.006**	-11.904	2.726	0.671	-6.847	0.686
	(0.003)	(12.544)	(10.811)	(0.533)	(4.111)	(28.945)
One product × X	0.008*	-22.696*	-12.091	0.390	-5.021	56.656**
	(0.004)	(12.311)	(15.837)	(0.765)	(7.026)	(26.429)
No. of students in each school-grade	0.001	-	-	-	-	-
	(0.003)					
R-squared	0.104	0.102	0.100	0.100	0.100	0.104
No. of obs.	845	846	846	846	846	846
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.23: Impacts on children's educational achievement - Math: complementarity (OLS)

Dependent variable:	Math: GPA z-scores					
X:	No. of students in each school-grade	School-level ratio of				
		no. of teachers to no. of students	no. of blackboards to no. of students	no. of benches to no. of students	no. of fans to no. of students	no. of toilets to no. of students
	(a)	(b)	(c)	(d)	(e)	(f)
December in 2013						
All products	-0.062	-0.280	-0.087	-0.201	-0.081	-0.099
	(0.144)	(0.209)	(0.179)	(0.272)	(0.056)	(0.090)
One product	0.278	0.160	0.208	0.186	-0.059	-0.247**
	(0.168)	(0.294)	(0.185)	(0.275)	(0.072)	(0.109)
All products × X	0.000	9.840	2.330	0.365	9.327***	14.852
	(0.003)	(8.425)	(8.381)	(0.558)	(3.057)	(19.291)
One product × X	-0.007**	-10.176	-15.387	-0.618	-5.285	42.326*
	(0.004)	(12.191)	(9.600)	(0.575)	(6.503)	(23.927)
No. of students in each school-grade	-0.006	-	-	-	-	-
	(0.007)					
R-squared	0.396	0.391	0.391	0.391	0.393	0.391
No. of obs.	849	850	850	850	850	850
	(g)	(h)	(i)	(j)	(k)	(l)
December in 2014						
All products	-0.523***	0.264	0.004	-0.572**	-0.096	-0.209
	(0.178)	(0.331)	(0.256)	(0.268)	(0.097)	(0.154)
One product	-0.065	0.529	0.134	-0.161	0.048	-0.221
	(0.268)	(0.342)	(0.247)	(0.395)	(0.096)	(0.150)
All products × X	0.008***	-15.263	-5.505	1.075*	-1.258	27.739
	(0.003)	(12.771)	(13.381)	(0.627)	(3.131)	(29.134)
One product × X	0.002	-20.467	-5.047	0.455	-2.238	68.518**
	(0.004)	(13.163)	(13.439)	(0.849)	(5.679)	(32.891)
No. of students in each school-grade	-0.001	-	-	-	-	-
	(0.004)					
R-squared	0.167	0.165	0.162	0.165	0.162	0.168
No. of obs.	845	846	846	846	846	846
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.24: Impacts on children's educational achievement - General science: complementarity (OLS)

Dependent variable:	General science: GPA z-scores					
X:	No. of students in each school-grade	School-level ratio of				
		no. of teachers to no. of students	no. of blackboards to no. of students	no. of benches to no. of students	no. of fans to no. of students	no. of toilets to no. of students
	(a)	(b)	(c)	(d)	(e)	(f)
December in 2013						
All products	0.122	-0.316	0.036	0.183	0.012	-0.054
	(0.214)	(0.298)	(0.365)	(0.391)	(0.086)	(0.098)
One product	0.412**	0.062	0.269	0.553*	0.065	-0.134
	(0.167)	(0.302)	(0.270)	(0.281)	(0.077)	(0.117)
All products × X	-0.001	15.216	0.768	-0.300	9.201**	27.496
	(0.003)	(11.079)	(16.472)	(0.808)	(4.047)	(26.193)
One product × X	-0.007**	-0.934	-12.144	-1.173*	-5.425	45.031*
	(0.003)	(12.333)	(13.003)	(0.599)	(7.647)	(26.201)
No. of students in each school-grade	-0.005	-	-	-	-	-
	(0.006)					
R-squared	0.303	0.299	0.298	0.300	0.301	0.300
No. of obs.	849	850	850	850	850	850
	(g)	(h)	(i)	(j)	(k)	(l)
December in 2014						
All products	-0.281	0.110	0.126	-0.319	-0.101	-0.178
	(0.209)	(0.302)	(0.226)	(0.223)	(0.091)	(0.142)
One product	-0.239	0.203	0.176	-0.168	-0.053	-0.296**
	(0.268)	(0.397)	(0.318)	(0.367)	(0.098)	(0.139)
All products × X	0.004	-8.855	-11.964	0.496	-0.099	19.661
	(0.003)	(12.302)	(11.357)	(0.450)	(3.506)	(27.584)
One product × X	0.003	-11.066	-12.549	0.241	-2.046	61.741**
	(0.005)	(14.569)	(14.982)	(0.797)	(8.351)	(30.417)
No. of students in each school-grade	-0.002	-	-	-	-	-
	(0.004)					
R-squared	0.150	0.149	0.150	0.149	0.148	0.153
No. of obs.	845	846	846	846	846	846
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.25: Impacts on children's educational achievement - Islam studies: complementarity (OLS)

Dependent variable:	Islam studies: GPA z-scores					
X:	No. of students in each school-grade	School-level ratio of no. of teachers to no. of students	no. of blackboards to no. of students	no. of benches to no. of students	no. of fans to no. of students	no. of toilets to no. of students
	(a)	(b)	(c)	(d)	(e)	(f)
December in 2013						
All products	0.020	-0.244	0.034	-0.112	0.021	0.016
	(0.203)	(0.342)	(0.330)	(0.361)	(0.087)	(0.111)
One product	0.419**	0.264	0.201	0.315	0.051	-0.143
	(0.166)	(0.338)	(0.225)	(0.335)	(0.078)	(0.130)
All products × X	0.001	12.312	1.021	0.381	7.859**	9.782
	(0.003)	(12.422)	(14.292)	(0.750)	(3.196)	(28.159)
One product × X	-0.008**	-10.056	-9.442	-0.670	-6.260	43.198
	(0.003)	(14.348)	(11.508)	(0.735)	(9.018)	(26.084)
No. of students in each school-grade	-0.008	-	-	-	-	-
	(0.006)					
R-squared	0.267	0.260	0.258	0.259	0.261	0.260
No. of obs.	849	850	850	850	850	850
	(g)	(h)	(i)	(j)	(k)	(l)
December in 2014						
All products	-0.289	0.282	0.084	-0.252	-0.033	-0.176
	(0.210)	(0.346)	(0.249)	(0.291)	(0.095)	(0.162)
One product	-0.207	0.577	0.366	0.012	0.078	-0.231
	(0.290)	(0.374)	(0.294)	(0.359)	(0.104)	(0.177)
All products × X	0.005	-14.241	-7.577	0.440	-6.024	30.325
	(0.003)	(13.749)	(12.760)	(0.609)	(5.255)	(31.724)
One product × X	0.005	-22.343	-17.042	0.067	-8.751	71.661**
	(0.005)	(14.165)	(15.323)	(0.816)	(9.306)	(34.321)
No. of students in each school-grade	0.001	-	-	-	-	-
	(0.004)					
R-squared	0.110	0.111	0.109	0.108	0.109	0.114
No. of obs.	845	846	846	846	846	846
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.26: Impacts on children's educational achievement - Bangladesh general studies: complementarity (OLS)

Dependent variable:	Bangladesh general studies: GPA z-scores					
X:	No. of students in each school-grade	School-level ratio of				
		no. of teachers to no. of students	no. of blackboards to no. of students	no. of benches to no. of students	no. of fans to no. of students	no. of toilets to no. of students
	(a)	(b)	(c)	(d)	(e)	(f)
December in 2013						
All products	0.082	-0.421*	-0.085	0.094	0.035	0.079
	(0.182)	(0.232)	(0.248)	(0.277)	(0.070)	(0.095)
One product	0.645***	-0.054	0.218	0.977***	0.154	-0.041
	(0.191)	(0.346)	(0.316)	(0.289)	(0.092)	(0.124)
All products × X	-0.000	20.199**	7.891	-0.064	7.221*	-4.123
	(0.003)	(8.743)	(11.756)	(0.596)	(3.713)	(21.890)
One product × X	-0.010***	7.378	-4.991	-1.944***	-6.654	43.299
	(0.003)	(13.510)	(14.799)	(0.614)	(9.324)	(27.714)
No. of students in each school-grade	-0.001	-	-	-	-	-
	(0.005)					
R-squared	0.279	0.273	0.270	0.279	0.273	0.273
No. of obs.	849	850	850	850	850	850
	(g)	(h)	(i)	(j)	(k)	(l)
December in 2014						
All products	-0.469**	-0.026	-0.187	-0.645**	-0.100	-0.128
	(0.193)	(0.351)	(0.292)	(0.293)	(0.099)	(0.155)
One product	-0.227	0.236	-0.049	-0.179	-0.002	-0.249
	(0.264)	(0.340)	(0.308)	(0.335)	(0.099)	(0.164)
All products × X	0.007**	-4.234	3.205	1.184*	-6.201	-0.391
	(0.003)	(13.329)	(14.375)	(0.629)	(5.100)	(29.385)
One product × X	0.004	-10.735	1.406	0.359	-4.828	60.456*
	(0.004)	(12.820)	(15.980)	(0.773)	(8.137)	(30.786)
No. of students in each school-grade	-0.007	-	-	-	-	-
	(0.005)					
R-squared	0.131	0.128	0.127	0.131	0.128	0.133
No. of obs.	845	846	846	846	846	846
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.27: Estimating non-attrition probability (OLS)

Dependent variable:	One if the outcome data are not missing						
Outcomes of interest:	Exam results in 2013	Exam results in 2014	Children's time use	Per-day hours using light sources	Log of expenditures (BDT)		
					Education	Kerosene	Total
	(a)	(b)	(c)	(d)	(e)	(f)	(g)
All products	0.016	0.010	0.008	0.016	0.010	-0.696***	0.016
	(0.011)	(0.012)	(0.034)	(0.012)	(0.013)	(0.060)	(0.012)
One product	0.024	0.029**	-0.000	0.020	0.029*	-0.053**	0.020
	(0.016)	(0.014)	(0.041)	(0.016)	(0.017)	(0.025)	(0.016)
HH baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.094	0.084	0.075	0.088	0.088	0.499	0.088
No. of obs.	882	882	882	882	882	882	882
No. of obs. having non-missing values at follow up							
	850	845	620	847	842	631	847

Notes: (1) A dependent variable is one if the outcome data are not missing at follow-up and zero otherwise. (2) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (3) Standard errors are robust to heteroskedasticity and clustered residuals within each village. (4) The baseline controls include household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.28: Lee (2009)'s 95% confidence intervals of the treatment effects

	Confidence interval		No. of obs.
	Lower bound	Upper bound	having non-missing values at follow-up
Examination results (2013)			
Progression	-0.031	0.099	850
Bengali	-0.094	0.220	850
English	-0.206	0.101	850
Math	-0.425	0.099	850
General science	-0.239	0.195	850
Islamic studies	-0.042	0.265	850
Bangladesh general studies	0.005	0.311	850
Examination results (2014)			
Progression	-0.104	0.035	845
Bengali	-0.210	0.484	846
English	-0.214	0.099	846
Math	-0.203	0.079	846
General science	-0.420	0.421	846
Islamic studies	-0.160	0.473	846
Bangladesh general studies	-0.268	0.023	846
Per-day minutes (average from Sep 2013 to Apr 2014) spent on:			
Study at school	-8.079	9.242	620
Study at home (total)	-1.265	25.375	620
Study at home (day)	-16.008	-2.208	620
Study at home (night)	11.719	29.442	620
Other activities	-38.530	29.535	620
Per-day hours using light sources			
Flashlight (rainy)	-0.319	-0.054	847
Flashlight (off-rainy)	-0.442	-0.061	847
Kerosene lanterns (rainy)	-0.850	-0.503	847
Kerosene lanterns (off-rainy)	-1.070	-0.657	847
Kerosene lamps (rainy)	-3.072	-2.450	847
Kerosene lamps (off-rainy)	-3.645	-2.845	847
Log of expenditures (BDT)			
Education	-0.088	0.119	842
Kerosene	-1.207	-0.626	631
Total	-0.092	0.006	847

Table S.29: Checking on spillover effects (OLS)

Dependent variable:	One if pass			
	Case A	Case B	Case C	Case D
	(a)	(b)	(c)	(d)
December 2012				
Share of treated students and their	-1.771*	0.826	-1.242	-0.854
siblings in each school-grade	(1.044)	(1.025)	(2.320)	(1.797)
Share of students in each school-grade that	0.976	-0.497	1.084	0.375
had no access to electricity at baseline	(0.965)	(0.545)	(1.195)	(0.860)
All products	0.001	-0.003	0.000	-0.000
	(0.030)	(0.030)	(0.030)	(0.030)
One product	-0.008	-0.014	-0.010	-0.012
	(0.040)	(0.040)	(0.040)	(0.040)
R-squared	0.222	0.215	0.216	0.213
No. of obs.	849	849	849	849
	(e)	(f)	(g)	(h)
December 2013				
Share of treated students and their	0.698	-0.162	0.667	0.486
siblings in each school-grade	(0.887)	(0.622)	(1.399)	(0.982)
Share of students in each school-grade that	-0.034	0.505	-0.283	0.042
had no access to electricity at baseline	(0.703)	(0.461)	(0.905)	(0.656)
All products	0.022	0.023	0.022	0.022
	(0.031)	(0.031)	(0.031)	(0.031)
One product	-0.005	-0.003	-0.004	-0.003
	(0.029)	(0.029)	(0.029)	(0.029)
R-squared	0.329	0.327	0.325	0.326
No. of obs.	849	849	849	849
	(i)	(j)	(k)	(l)
December 2014				
Share of treated students and their	0.764	-0.333	0.341	0.287
siblings in each school-grade	(0.679)	(0.397)	(1.151)	(0.799)
Share of students in each school-grade that	0.134	0.764***	-0.057	0.285
had no access to electricity at baseline	(0.531)	(0.280)	(0.744)	(0.457)
All products	-0.058	-0.057	-0.058	-0.057
	(0.042)	(0.042)	(0.042)	(0.042)
One product	-0.031	-0.028	-0.028	-0.028
	(0.039)	(0.039)	(0.038)	(0.038)
R-squared	0.154	0.153	0.148	0.150
No. of obs.	844	844	844	844
Baseline control	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.30: Checking on spillover effects - GPA z-scores: Case A (OLS)

Dependent variables:	GPA z-scores					
	Bengali	English	Math	General science	Islam studies	Bangladesh general studies
	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)
December 2012						
Share of treated students and their siblings in each school-grade	-4.573*	-3.062	-4.573*	-3.494	-4.011	-2.085
	(2.568)	(2.290)	(2.366)	(2.395)	(2.852)	(1.734)
Share of students in each school-grade that had no access to electricity at baseline	3.451	2.352	3.349	2.844	2.444	1.690
	(2.389)	(2.424)	(2.451)	(2.386)	(2.751)	(1.638)
All products	-0.018	-0.035	0.005	-0.032	-0.095	-0.078
	(0.080)	(0.078)	(0.070)	(0.073)	(0.072)	(0.089)
One product	-0.019	0.006	0.022	-0.004	-0.107	-0.086
	(0.096)	(0.081)	(0.096)	(0.105)	(0.087)	(0.095)
R-squared	0.232	0.220	0.218	0.217	0.231	0.225
No. of obs.	849	849	849	849	849	849
	(2a)	(2b)	(2c)	(2d)	(2e)	(2f)
December 2013						
Share of treated students and their siblings in each school-grade	-1.546	3.335	-4.084*	-6.019***	-3.535	0.317
	(2.009)	(2.385)	(2.187)	(1.892)	(2.155)	(1.678)
Share of students in each school-grade that had no access to electricity at baseline	0.324	-3.599	2.413	3.287*	3.441*	-0.075
	(1.889)	(2.429)	(2.054)	(1.752)	(1.999)	(1.715)
All products	-0.044	-0.062	-0.034	0.062	0.061	0.065
	(0.085)	(0.063)	(0.058)	(0.084)	(0.081)	(0.069)
One product	0.029	-0.145**	-0.068	0.059	0.033	0.128
	(0.085)	(0.069)	(0.071)	(0.078)	(0.078)	(0.089)
R-squared	0.260	0.263	0.398	0.318	0.266	0.272
No. of obs.	849	849	849	849	849	849
	(3a)	(3b)	(3c)	(3d)	(3e)	(3f)
December 2014						
Share of treated students and their siblings in each school-grade	0.499	0.273	1.239	1.548	0.714	2.043*
	(1.033)	(1.052)	(1.359)	(1.126)	(1.010)	(1.170)
Share of students in each school-grade that had no access to electricity at baseline	0.360	0.340	-0.133	-0.791	0.207	-0.819
	(0.972)	(0.914)	(1.127)	(0.995)	(0.897)	(0.908)
All products	-0.085	-0.035	-0.103	-0.104	-0.059	-0.129
	(0.082)	(0.085)	(0.087)	(0.081)	(0.088)	(0.090)
One product	0.051	0.041	0.033	-0.073	0.032	-0.036
	(0.092)	(0.086)	(0.089)	(0.092)	(0.100)	(0.092)
R-squared	0.115	0.099	0.164	0.150	0.109	0.130
No. of obs.	845	845	845	845	845	845
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.31: Checking on spillover effects - GPA z-scores: Case B (OLS)

Dependent variables:	GPA z-scores					
	Bengali	English	Math	General science	Islam studies	Bangladesh general studies
	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)
December 2012						
Share of treated students and their	1.067	2.626	2.822	0.408	-0.467	-0.826
siblings in each school-grade	(1.851)	(2.218)	(2.505)	(2.753)	(2.036)	(1.362)
Share of students in each school-grade that	-0.082	-0.498	-0.627	0.248	-0.300	0.411
had no access to electricity at baseline	(1.208)	(1.539)	(1.423)	(1.486)	(1.278)	(0.836)
All products	-0.027	-0.042	-0.006	-0.038	-0.102	-0.081
	(0.080)	(0.077)	(0.069)	(0.073)	(0.072)	(0.089)
One product	-0.035	-0.004	0.006	-0.017	-0.121	-0.093
	(0.095)	(0.080)	(0.095)	(0.104)	(0.085)	(0.094)
R-squared	0.222	0.219	0.212	0.211	0.223	0.223
No. of obs.	849	849	849	849	849	849
	(2a)	(2b)	(2c)	(2d)	(2e)	(2f)
December 2013						
Share of treated students and their	1.319	-0.586	3.618*	3.584*	1.880	-1.158
siblings in each school-grade	(1.988)	(3.003)	(1.904)	(1.927)	(2.022)	(1.869)
Share of students in each school-grade that	-1.113	-1.072	-1.416	-1.915	0.443	0.445
had no access to electricity at baseline	(1.482)	(1.878)	(1.237)	(1.482)	(1.323)	(1.501)
All products	-0.048	-0.056	-0.044	0.049	0.054	0.066
	(0.087)	(0.064)	(0.058)	(0.084)	(0.083)	(0.070)
One product	0.024	-0.133*	-0.081	0.039	0.022	0.128
	(0.086)	(0.071)	(0.072)	(0.078)	(0.079)	(0.089)
R-squared	0.259	0.257	0.398	0.308	0.262	0.272
No. of obs.	849	849	849	849	849	849
	(3a)	(3b)	(3c)	(3d)	(3e)	(3f)
December 2014						
Share of treated students and their	-2.826***	0.394	0.660	-1.869	-2.793*	-4.240***
siblings in each school-grade	(0.884)	(0.817)	(1.256)	(1.182)	(1.402)	(1.292)
Share of students in each school-grade that	1.429***	0.435	0.585	0.787	1.422***	1.711***
had no access to electricity at baseline	(0.414)	(0.437)	(0.637)	(0.507)	(0.516)	(0.547)
All products	-0.082	-0.035	-0.101	-0.100	-0.056	-0.122
	(0.082)	(0.085)	(0.088)	(0.081)	(0.088)	(0.091)
One product	0.052	0.043	0.038	-0.068	0.033	-0.030
	(0.092)	(0.086)	(0.088)	(0.092)	(0.099)	(0.093)
R-squared	0.120	0.100	0.163	0.152	0.113	0.139
No. of obs.	845	845	845	845	845	845
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.32: Checking on spillover effects - GPA z-scores: Case C (OLS)

Dependent variables:	GPA z-scores					
	Bengali	English	Math	General science	Islam studies	Bangladesh general studies
	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)
December 2012						
Share of treated students and their	-5.774	-0.015	-2.177	-5.327	-7.649**	-5.339**
siblings in each school-grade	(3.885)	(4.967)	(5.418)	(6.261)	(3.592)	(2.519)
Share of students in each school-grade that	4.358*	1.452	2.904	3.809	4.469*	3.105*
had no access to electricity at baseline	(2.393)	(2.938)	(2.866)	(3.143)	(2.519)	(1.537)
All products	-0.017	-0.039	0.002	-0.030	-0.092	-0.075
	(0.081)	(0.078)	(0.069)	(0.072)	(0.073)	(0.089)
One product	-0.020	0.001	0.016	-0.004	-0.106	-0.083
	(0.096)	(0.080)	(0.095)	(0.104)	(0.086)	(0.094)
R-squared	0.231	0.220	0.215	0.217	0.232	0.227
No. of obs.	849	849	849	849	849	849
	(2a)	(2b)	(2c)	(2d)	(2e)	(2f)
December 2013						
Share of treated students and their	0.356	5.075	0.529	-2.639	-2.667	-1.866
siblings in each school-grade	(3.980)	(4.789)	(3.952)	(4.018)	(4.251)	(4.197)
Share of students in each school-grade that	0.069	-4.168	1.286	3.055	3.142	0.675
had no access to electricity at baseline	(2.418)	(2.926)	(2.321)	(2.336)	(2.451)	(2.475)
All products	-0.046	-0.064	-0.040	0.057	0.060	0.067
	(0.087)	(0.064)	(0.058)	(0.084)	(0.082)	(0.069)
One product	0.024	-0.147**	-0.077	0.050	0.032	0.131
	(0.087)	(0.069)	(0.072)	(0.079)	(0.080)	(0.090)
R-squared	0.257	0.263	0.395	0.305	0.266	0.272
No. of obs.	849	849	849	849	849	849
	(3a)	(3b)	(3c)	(3d)	(3e)	(3f)
December 2014						
Share of treated students and their	-5.178**	1.034	3.136	-1.262	-4.742**	-5.355**
siblings in each school-grade	(1.951)	(1.861)	(2.725)	(2.142)	(2.195)	(2.577)
Share of students in each school-grade that	2.217*	-0.197	-1.304	-0.002	1.955*	1.560
had no access to electricity at baseline	(1.238)	(1.155)	(1.611)	(1.211)	(1.084)	(1.335)
All products	-0.078	-0.036	-0.105	-0.101	-0.053	-0.120
	(0.082)	(0.085)	(0.088)	(0.081)	(0.089)	(0.090)
One product	0.059	0.042	0.033	-0.068	0.040	-0.025
	(0.092)	(0.086)	(0.088)	(0.092)	(0.099)	(0.092)
R-squared	0.118	0.099	0.163	0.150	0.111	0.135
No. of obs.	845	845	845	845	845	845
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.33: Checking on spillover effects - GPA z-scores: Case D (OLS)

Dependent variables:	GPA z-scores					
	Bengali	English	Math	General science	Islam studies	Bangladesh general studies
	(1a)	(1b)	(1c)	(1d)	(1e)	(1f)
December 2012						
Share of treated students and their	-3.558	0.400	-1.481	-4.135	-5.630**	-3.723*
siblings in each school-grade	(3.030)	(3.709)	(4.182)	(4.717)	(2.669)	(1.956)
Share of students in each school-grade that	2.176	0.156	1.149	2.460	2.406	2.073*
had no access to electricity at baseline	(1.624)	(2.301)	(2.156)	(2.387)	(1.753)	(1.080)
All products	-0.020	-0.041	-0.001	-0.031	-0.094	-0.076
	(0.081)	(0.078)	(0.069)	(0.072)	(0.072)	(0.089)
One product	-0.027	-0.005	0.009	-0.007	-0.110	-0.085
	(0.095)	(0.078)	(0.093)	(0.103)	(0.085)	(0.094)
R-squared	0.225	0.215	0.208	0.216	0.231	0.226
No. of obs.	849	849	849	849	849	849
	(2a)	(2b)	(2c)	(2d)	(2e)	(2f)
December 2013						
Share of treated students and their	0.214	3.376	1.312	-0.948	-1.473	-1.442
siblings in each school-grade	(3.019)	(3.542)	(3.182)	(3.334)	(3.254)	(3.025)
Share of students in each school-grade that	-0.552	-3.034	-0.422	0.385	1.791	0.711
had no access to electricity at baseline	(2.004)	(2.628)	(1.705)	(1.973)	(1.878)	(2.148)
All products	-0.047	-0.063	-0.043	0.053	0.058	0.068
	(0.087)	(0.064)	(0.057)	(0.084)	(0.082)	(0.069)
One product	0.022	-0.142*	-0.084	0.040	0.026	0.132
	(0.088)	(0.070)	(0.072)	(0.079)	(0.081)	(0.090)
R-squared	0.258	0.263	0.390	0.297	0.262	0.272
No. of obs.	849	849	849	849	849	849
	(3a)	(3b)	(3c)	(3d)	(3e)	(3f)
December 2014						
Share of treated students and their	-4.198***	0.829	2.445	-1.269	-3.809**	-4.219**
siblings in each school-grade	(1.519)	(1.410)	(1.943)	(1.772)	(1.790)	(2.031)
Share of students in each school-grade that	2.304**	-0.043	-0.695	0.575	2.136**	2.215*
had no access to electricity at baseline	(0.913)	(0.838)	(1.150)	(0.928)	(0.900)	(1.133)
All products	-0.077	-0.036	-0.104	-0.099	-0.051	-0.118
	(0.082)	(0.085)	(0.087)	(0.081)	(0.089)	(0.090)
One product	0.062	0.041	0.033	-0.065	0.043	-0.020
	(0.092)	(0.086)	(0.087)	(0.091)	(0.099)	(0.092)
R-squared	0.119	0.099	0.164	0.149	0.111	0.131
No. of obs.	845	845	845	845	845	845
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.34: Impacts on children's educational achievement: mid-term examination results (OLS)

Dependent variables:	GPA z-scores					
	Bengali	Bengali	English	English	Math	Math
	(a)	(b)	(c)	(d)	(e)	(f)
June 2014						
All products	0.048	0.048	-0.018	0.019	-0.017	-0.006
	(0.185)	(0.151)	(0.141)	(0.134)	(0.143)	(0.141)
One product	0.157	0.100	0.029	0.035	-0.036	-0.042
	(0.170)	(0.171)	(0.112)	(0.126)	(0.151)	(0.170)
All = one (p-val.)	0.550	0.775	0.754	0.922	0.897	0.836
All + one = 0 (p-val.)	0.511	0.585	0.957	0.787	0.840	0.858
Mean y (control)	-0.042	-0.042	-0.034	-0.034	0.028	0.028
R-squared	0.293	0.391	0.393	0.440	0.355	0.363
No. of obs.	284	284	284	284	283	283
Dependent var.	General science	General science	Islam studies	Islam studies	Bangladesh general studies	Bangladesh general studies
	(g)	(h)	(i)	(j)	(k)	(l)
June 2014						
All products	-0.392*	-0.397*	0.010	-0.023	0.041	0.034
	(0.201)	(0.191)	(0.172)	(0.175)	(0.161)	(0.164)
One product	-0.281	-0.363*	0.068	-0.006	0.062	0.046
	(0.205)	(0.182)	(0.136)	(0.144)	(0.189)	(0.216)
All = one (p-val.)	0.371	0.808	0.730	0.933	0.897	0.955
All + one = 0 (p-val.)	0.101	0.042	0.768	0.908	0.745	0.809
Mean y (control)	0.165	0.165	0.014	0.014	0.001	0.001
R-squared	0.213	0.319	0.329	0.393	0.219	0.241
No. of obs.	283	283	284	284	284	284
Baseline control	No	Yes	No	Yes	No	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) Figures ( ) are standard errors. *** denotes significance at 1%, ** at 5%, and * at 10%. (2) Standard errors are robust to heteroskedasticity and clustered residuals within each school-grade. (3) The baseline controls include age (years); education (years); gender (dummy); household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number).

Table S.35: Checking on multiple-hypothesis testing

Dependent variables:	One if pass	
	Dec. 2013	Dec. 2014
	(a)	(b)
Any product	0.011	-0.043
Original p-values	(0.660)	(0.226)
Adjusted p-values		
Bonferroni	(1.000)	(1.000)
Holm (1979)	(1.000)	(1.000)
R-squared	0.324	0.145
No. of obs.	850	845

Dependent variables:	Per-day hours using light sources			Log of expenditures		
	Flashlight (total)	Kerosene lanterns (total)	Kerosene lamps (total)	Education	Kerosene	Total
	(c)	(d)	(e)	(f)	(g)	(h)
Any product	-0.349*	-1.474***	-5.986***	0.025	-0.829***	-0.040***
Original p-values	(0.059)	(0.000)	(0.000)	(0.483)	(0.000)	(0.001)
Adjusted p-values						
Bonferroni	(0.820)	(0.000)	(0.000)	(1.000)	(0.000)	(0.015)
Holm (1979)	(0.351)	(0.000)	(0.000)	(1.000)	(0.000)	(0.010)
R-squared	0.058	0.175	0.383	0.220	0.390	0.472
No. of obs.	847	847	847	842	631	847

Dependent variables:	Per-day minutes (average from Sep 2013 to Apr 2014) spent on:					One if attend
	Study at school	Study at home (total)	Study at home (day)	Study at home (night)	Other	
	(i)	(j)	(k)	(l)	(m)	(n)
Any product	2.198	15.628***	-6.177**	21.805***	-6.031	0.063***
Original p-values	(0.420)	(0.004)	(0.011)	(0.000)	(0.506)	(0.006)
Adjusted p-values						
Bonferroni	(1.000)	(0.056)	(0.159)	(0.000)	(1.000)	(0.089)
Holm (1979)	(1.000)	(0.036)	(0.079)	(0.000)	(1.000)	(0.051)
R-squared	0.137	0.172	0.211	0.219	0.451	0.154
No. of obs.	620	620	620	620	620	2646
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes
School FE	Yes	Yes	Yes	Yes	Yes	Yes
Village FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: (1) *** denotes significance at 1%, ** at 5%, and * at 10%, corresponding to the original p-values based on standard errors robust to heteroskedasticity and clustered residuals within each village in columns (c) to (h) and within school-grade in the remaining columns. (2) In columns (c) to (h), the baseline controls include household size; no. of males; head age (years); head education (years); head gender (dummy); and land size (natural number). In the remaining columns, the baseline controls additionally include age (years); education (years); and gender (dummy).